United States
Department of
Agriculture

Natural
Resources
Conservation
Service

United States
Department of
the Interior

National Park
Service

Soil Survey of Cabrillo National Monument, California

How To Use This Soil Survey

This publication consists of text, tables, and a map. The text includes descriptions of detailed soil map units and provides an explanation of the information presented in the tables. It also includes a glossary of terms used in the text and tables and a list of references.

The detailed soil map can be useful in planning the use and management of small areas. To find information about your area of interest, locate that area on the map sheet. Note the map unit symbols that are in that area. Go to the **Contents**, which lists the map units by symbol and name and shows where each map unit is described.

The **Contents** shows which table has data on a specific land use for each detailed soil map unit. Also see the **Contents** for sections of this publication that may address your specific needs.

National Cooperative Soil Survey

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

The soil map in this survey may be copied without permission. Enlargement of the map, however, could cause misunderstanding of the detail of mapping. If enlarged, the map does not show the small areas of contrasting soils that could have been shown at a larger scale.

Literature Citation

The recommended citation for this survey is:

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Cover Caption

The historic Point Loma Lighthouse at Cabrillo National Monument. The lighthouse is on a beach ridge in an area of Carlsbad gravelly loamy sand, 5 to 9 percent slopes. The side slopes are areas of Gaviota fine sandy loam, 30 to 50 percent slopes.

Additional information about the Nation's natural resources is available online from the Natural Resources Conservation Service at http://www.nrcs.usda.gov/.

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Contents

Issued 2013

Preface

This soil survey was developed in conjunction with the National Park Service's Soil Inventory and Monitoring Program and is intended to serve as the official source document for soils within Cabrillo National Monument, California.

This soil survey contains information that affects current and future land use planning in the park. It contains predictions of soil behavior for selected land uses. The survey highlights soil limitations, actions needed to overcome the limitations, and the impact of selected land uses on the environment. It is designed to meet the needs of the National Park Service and its partners to better understand the properties of the soils in the park and the effects of these properties on various natural ecological characteristics. This knowledge can help the National Park Service and its partners to understand, protect, and enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. The information in this report is intended to identify soil properties that are used in making various land use or land treatment decisions. Statements made in this report are intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. The location of each map unit is shown on the detailed soil map. Each soil in the survey area is described, and information on specific uses is given. Help in using this publication and additional information are available at the local office of the Natural Resources Conservation Service or the park office for Cabrillo National Monument.

Soil Survey of Cabrillo National Monument, California

United States Department of Agriculture, Natural Resources Conservation Service, and United States Department of the Interior, National Park Service

Cabrillo National Monument is located at the tip of Point Loma Peninsula, directly west of the city of San Diego, California (figs. 1 and 2). This survey was made in conjunction with the National Park Service's Soil Inventory and Monitoring Program to provide information about the soils and miscellaneous areas within Cabrillo National Monument.

How This Survey Was Made

The soil survey data for Cabrillo National Monument was extracted in 2011 from the soil survey of San Diego County Area, California. The survey of San Diego County Area was initiated in the 1960s by the United States Department of Agriculture, Soil Conservation Service (now the Natural Resources Conservation Service) and was correlated in 1967. Mapping was conducted at a scale of 1:24,000. The last certification of the data set by NRCS was in 2002, and the data set is currently considered in need of an update. The data set included 8 map units and 36 map unit components within the boundary of Cabrillo National Monument. For this survey, data were not extracted for the map unit components of limited composition.

Figure 1.—Location of Cabrillo National Monument near the city of San Diego, California (USDI–NPS, 2002).

Faculty from the soils department of the University of California, Davis, provided a technical review of the Soil Formation section of this document.

The information in this survey includes a description of the soils and miscellaneous areas and their location and a discussion of their suitability, limitations, and management for specified uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of native plants; and the kinds of bedrock. They dug many

holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

The soils and miscellaneous areas in the survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

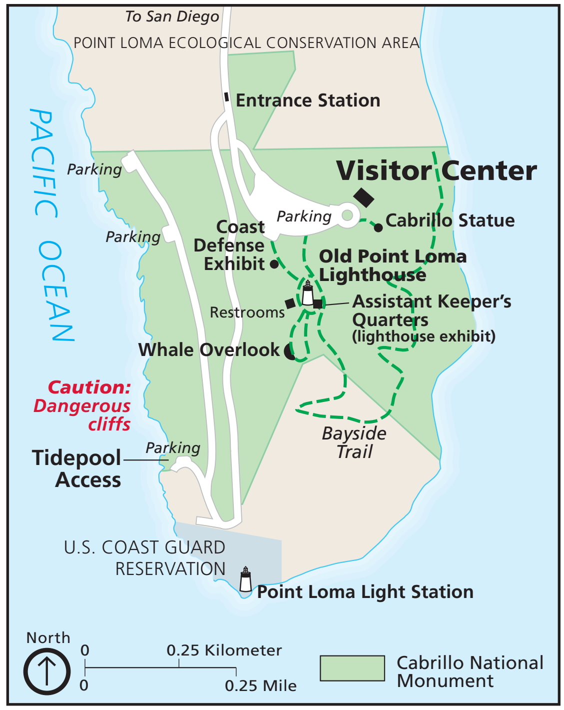

Figure 2.—Map of Cabrillo National Monument (USDI–NPS, 2007).

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units).

Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet

local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they delineated the boundaries of these bodies on digital imagery and identified each as a specific map unit.

Detailed Soil Map Units

The map units delineated on the detailed soil map in this survey represent the soils or miscellaneous areas in the park. The map unit descriptions in this section, along with the map, can be used to determine the suitability and potential of a unit for specific uses. They also can be used to plan the management needed for those uses.

A map unit delineation on the soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the map. The contrasting components are mentioned in the map unit descriptions. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. The soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil map are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example,

Carlsbad gravelly loamy sand, 5 to 9 percent slopes, is a phase of the Carlsbad series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Loamy alluvial land-Huerhuero complex, 9 to 50 percent slopes, severely eroded, is an example.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Steep gullied land is an example.

Table 1 lists the components of each map unit in the park. Other tables give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils.

456763—Carlsbad gravelly loamy sand, 5 to 9 percent slopes

Map Unit Setting

Major land resource area (MLRA): 19—Southern California Coastal Plain
Mean annual precipitation: 10 to 16 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 330 to 350 days

Map Unit Composition

Carlsbad and similar soils: 85 percent

Description of Carlsbad Soil

Taxonomic Classification
Sandy, mixed, thermic Entic Durixerepts

Setting
Landform: Ridges and swales on hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Slope: 5 to 9 percent
Down-slope shape: Convex
Across-slope shape: Convex
Aspect (representative): West
Aspect (range): Northeast to northwest (clockwise)
Soil temperature class: Thermic
Soil temperature regime: Thermic

Properties and Qualities
Runoff: Low
Parent material: Ferruginous sandstone
Restrictive feature(s): Weakly cemented duripan at a depth of 24 to 40 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Moderately well drained
Shrink-swell potential: Low (about 1.5 percent linear extensibility)
Salinity, maximum: Not saline
Sodicity, maximum: Not sodic

Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Very low (about 2.7 inches)

Interpretive Groups
Land capability classification (nonirrigated): 3e
Meets hydric soil criteria: No
Hydrologic soil group: C

Typical Profile
0 to 21 inches; gravelly loamy sand
21 to 39 inches; loamy sand
39 to 50 inches; indurated

456764—Carlsbad gravelly loamy sand, 9 to 15 percent slopes

Map Unit Setting

Major land resource area (MLRA): 19—Southern California Coastal Plain
Mean annual precipitation: 10 to 16 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 330 to 350 days

Map Unit Composition

Carlsbad and similar soils: 85 percent

Description of Carlsbad Soil

Taxonomic Classification
Sandy, mixed, thermic Entic Durixerepts

Setting
Landform: Ridges and swales on hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Slope: 9 to 15 percent
Down-slope shape: Convex
Across-slope shape: Convex
Aspect (representative): Southwest
Aspect (range): Northeast to west (clockwise)
Soil temperature class: Thermic
Soil temperature regime: Thermic

Properties and Qualities
Runoff: Low
Parent material: Ferruginous sandstone
Restrictive feature(s): Weakly cemented duripan at a depth of 24 to 40 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Moderately well drained
Shrink-swell potential: Low (about 1.5 percent linear extensibility)
Salinity, maximum: Not saline
Sodicity, maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Very low (about 2.2 inches)

Interpretive Groups
Land capability classification (nonirrigated): 4e
Meets hydric soil criteria: No
Hydrologic soil group: C

Typical Profile
0 to 21 inches; gravelly loamy sand
21 to 33 inches; loamy sand
33 to 50 inches; indurated

456822—Gaviota fine sandy loam, 9 to 30 percent slopes

Map Unit Setting

Major land resource area (MLRA): 20—Southern California Mountains
Mean annual precipitation: 20 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 330 to 350 days

Map Unit Composition

Gaviota and similar soils: 85 percent

Description of Gaviota Soil

Taxonomic Classification
Loamy, mixed, superactive, nonacid, thermic Lithic Xerorthents

Setting
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Slope: 9 to 30 percent
Down-slope shape: Convex
Across-slope shape: Convex
Aspect (representative): West
Aspect (range): Northeast to north (clockwise)
Soil temperature class: Thermic
Soil temperature regime: Thermic

Properties and Qualities
Runoff: Medium
Parent material: Residuum weathered from calcareous sandstone
Restrictive feature(s): Lithic bedrock at a depth of 10 to 20 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: Low (about 1.5 percent linear extensibility)
Salinity, maximum: Not saline
Sodicity, maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Very low (about 1.9 inches)

Interpretive Groups
Land capability classification (nonirrigated): 4e
Meets hydric soil criteria: No
Hydrologic soil group: D

Vegetation
Existing plants: Chamise, manzanita, red brome, buckbrush, California yerba santa, stork's bill, oak, and squirreltail

Typical Profile
0 to 16 inches; fine sandy loam
16 to 20 inches; unweathered bedrock

456823—Gaviota fine sandy loam, 30 to 50 percent slopes

Map Unit Setting

Major land resource area (MLRA): 20—Southern California Mountains
Mean annual precipitation: 20 inches
Mean annual air temperature: 61 degrees F
Frost-free period: 330 to 350 days

Map Unit Composition

Gaviota and similar soils: 85 percent

Description of Gaviota Soil

Taxonomic Classification
Loamy, mixed, superactive, nonacid, thermic Lithic Xerorthents

Setting
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Slope: 30 to 50 percent
Down-slope shape: Convex
Across-slope shape: Convex
Aspect (representative): West
Aspect (range): Northeast to northwest (clockwise)
Soil temperature class: Thermic
Soil temperature regime: Thermic

Properties and Qualities
Runoff: Medium
Parent material: Residuum weathered from calcareous sandstone
Restrictive feature(s): Lithic bedrock at a depth of 10 to 20 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: Low (about 1.5 percent linear extensibility)
Salinity, maximum: Not saline
Sodicity, maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Very low (about 1.9 inches)

Interpretive Groups
Land capability classification (nonirrigated): 6e
Meets hydric soil criteria: No
Hydrologic soil group: D

Vegetation
Existing plants: Chamise, manzanita, red brome, buckbrush, California yerba santa, stork's bill, oak, and squirreltail

Typical Profile
0 to 16 inches; fine sandy loam
16 to 20 inches; unweathered bedrock

456875—Loamy alluvial land-Huerhuero complex, 9 to 50 percent slopes, severely eroded

Map Unit Setting

Major land resource area (MLRA): 19—Southern California Coastal Plain
Mean annual precipitation: 8 to 20 inches
Mean annual air temperature: 57 to 64 degrees F
Frost-free period: 330 to 350 days

Map Unit Composition

Huerhuero and similar soils: 30 percent
Loamy alluvial land: 30 percent

Description of Huerhuero Soil

Taxonomic Classification
Fine, smectitic, thermic Typic Natrixeralfs

Setting
Landscape: Coastal plains
Landform: Ridges
Slope: 15 to 30 percent
Down-slope shape: Concave
Across-slope shape: Concave
Aspect (representative): West
Aspect (range): Northeast to northwest (clockwise)
Soil temperature class: Thermic
Soil temperature regime: Thermic

Properties and Qualities
Runoff: Very high
Parent material: Residuum weathered from calcareous sandstone and shale
Restrictive feature(s): None within a depth of 60 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Moderately well drained
Shrink-swell potential: High (about 7.5 percent linear extensibility)
Salinity, maximum: Nonsaline (about 1.0 mmho/cm)
Sodicity, maximum: Sodium adsorption ratio of 18.0
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Low (about 3.9 inches)

Interpretive Groups
Land capability classification (nonirrigated): 7e
Meets hydric soil criteria: No
Hydrologic soil group: D

Typical Profile
0 to 1 inch; loam
1 to 40 inches; clay and clay loam
40 to 60 inches; stratified sand to sandy loam

Description of Loamy Alluvial Land

Setting
Landscape: Coastal plains
Landform: Drainageways
Slope: 9 to 50 percent
Aspect (representative): North

Properties and Qualities
Runoff: High
Parent material: Alluvium derived from mixed sources
Restrictive feature(s): None within a depth of 60 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Salinity, maximum: Not saline
Sodicity, maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0

Interpretive Groups
Land capability classification (nonirrigated): 7e
Meets hydric soil criteria: No
Hydrologic soil group: B

Typical Profile
0 to 60 inches; variable

456912—Reiff fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

Major land resource area (MLRA): 19—Southern California Coastal Plain
Mean annual precipitation: 10 to 20 inches
Mean annual air temperature: 61 to 63 degrees F
Frost-free period: 330 to 350 days

Map Unit Composition

Reiff and similar soils: 85 percent

Description of Reiff Soil

Taxonomic Classification
Coarse-loamy, superactive, mixed, nonacid, thermic Mollic Xerofluvents

Setting
Landform: Alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope and riser
Slope: 0 to 2 percent
Down-slope shape: Linear
Across-slope shape: Convex
Aspect (representative): South
Aspect (range): Northeast to north (clockwise)

Soil temperature class: Thermic
Soil temperature regime: Thermic

Properties and Qualities
Runoff: Very low
Parent material: Alluvium derived from granite
Restrictive feature(s): None within a depth of 60 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: Low (about 1.5 percent linear extensibility)
Salinity, maximum: Nonsaline (about 1.0 mmho/cm)
Sodicity, maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Moderate (about 8.6 inches)

Interpretive Groups
Land capability classification (nonirrigated): 3c
Meets hydric soil criteria: No
Hydrologic soil group: B

Typical Profile
0 to 14 inches; fine sandy loam
14 to 43 inches; stratified sandy loam to loam
43 to 60 inches; stratified sandy loam to loam

456914—Reiff fine sandy loam, 5 to 9 percent slopes

Map Unit Setting

Major land resource area (MLRA): 19—Southern California Coastal Plain
Mean annual precipitation: 10 to 20 inches
Mean annual air temperature: 61 to 63 degrees F
Frost-free period: 330 to 350 days

Map Unit Composition

Reiff and similar soils: 85 percent

Description of Reiff Soil

Taxonomic Classification
Coarse-loamy, superactive, mixed, nonacid, thermic Mollic Xerofluvents

Setting
Landform: Alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope and riser
Slope: 5 to 9 percent
Down-slope shape: Linear
Across-slope shape: Convex
Aspect (representative): Southwest
Aspect (range): Northeast to west (clockwise)
Soil temperature class: Thermic
Soil temperature regime: Thermic

Properties and Qualities
Runoff: Low

Parent material: Alluvium derived from granite
Restrictive feature(s): None within a depth of 60 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Drainage class: Well drained
Shrink-swell potential: Low (about 1.5 percent linear extensibility)
Salinity, maximum: Nonsaline (about 1.0 mmho/cm)
Sodicity, maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0
Available water capacity: Moderate (about 8.6 inches)

Interpretive Groups
Land capability classification (nonirrigated): 3e
Meets hydric soil criteria: No
Hydrologic soil group: B

Typical Profile
0 to 14 inches; fine sandy loam
14 to 43 inches; stratified sandy loam to loam
43 to 60 inches; stratified sandy loam to loam

456932—Steep gullied land

Map Unit Setting

Major land resource area (MLRA): 20—Southern California Mountains

Map Unit Composition

Steep gullied land: 85 percent

Description of Steep Gullied Land

Setting
Landscape: Alluvial plain remnants
Landform: Gullies
Landform position (three-dimensional): Riser
Slope: 15 to 60 percent
Aspect (representative): South
Aspect (range): Northeast to west (clockwise)

Properties and Qualities
Runoff: Very high
Restrictive feature(s): None within a depth of 60 inches
Frequency of flooding: None
Frequency of ponding: None
Depth to water table: More than 72 inches
Salinity, maximum: Not saline
Sodicity, maximum: Not sodic
Calcium carbonate equivalent (maximum weight percentage): 0

Interpretive Groups
Land capability classification (nonirrigated): 8
Meets hydric soil criteria: No

Typical Profile
0 to 60 inches; variable

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the park. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help to prevent soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavioral characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as forestland; and as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreational facilities. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the park. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of gravel, sand, reclamation material, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, and campgrounds.

Interpretive Ratings

The interpretive tables in this survey rate the soils in the park for various uses. Many of the tables identify the limitations that affect specified uses and indicate the severity of those limitations. The ratings in these tables are both verbal and numerical.

Rating Class Terms

Rating classes are expressed in the tables in terms that indicate the extent to which the soils are limited by all of the soil features that affect a specified use or in terms that indicate the suitability of the soils for the use. Thus, the tables may show limitation classes or suitability classes. Terms for the limitation classes are *not limited, somewhat limited,* and *very limited*. The suitability ratings are expressed as *well suited, moderately suited, poorly suited,* and *unsuited* or as *good, fair,* and *poor*.

Numerical Ratings

Numerical ratings in the tables indicate the relative severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.00 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use and the point at which the soil feature is not a limitation. The limitations

appear in order from the most limiting to the least limiting. Thus, if more than one limitation is identified, the most severe limitation is listed first and the least severe one is listed last.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forestland, or for engineering purposes.

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit (USDA–SCS, 1961).

Capability classes, the broadest groups, are designated by the numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class 1 soils have slight limitations that restrict their use.

Class 2 soils have moderate limitations that restrict the choice of plants or that require moderate conservation practices.

Class 3 soils have severe limitations that restrict the choice of plants or that require special conservation practices, or both.

Class 4 soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.

Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.

Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, 2e. The letter *e* shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c,* used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by *w, s,* or *c* because the soils in class 5 are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, forestland, wildlife habitat, or recreation.

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4 and 3e-6. These units are not given in all soil surveys.

The capability classification of the soils in this park is given in the section "Detailed Soil Map Units" and in table 2.

Prime Farmland and Other Important Farmland

Table 3 lists the map units in the park that are considered prime farmland and farmland of statewide importance. This list does not constitute a recommendation for a particular land use.

In an effort to identify the extent and location of important farmlands, the Natural Resources Conservation Service, in cooperation with other interested Federal, State, and local government organizations, has inventoried land that can be used for the production of the Nation's food supply.

Prime farmland is of major importance in meeting the Nation's short- and long-range needs for food and fiber. Because the supply of high-quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is available for these uses. It could be cultivated land, pastureland, forestland, or other land, but it is not urban or built-up land or water areas. The soil quality, growing season, and moisture supply are those needed for the soil to economically produce sustained high yields of crops when proper management, including water management, and acceptable farming methods are applied. In general, prime farmland has an adequate and dependable supply of moisture from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, an acceptable salt and sodium content, and few or no rocks. The water supply is dependable and of adequate quality. Prime farmland is permeable to water and air. It is not excessively erodible or saturated with water for long periods, and it either is not frequently flooded during the growing season or is protected from flooding. Slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Natural Resources Conservation Service.

A recent trend in land use in some areas has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated.

For one soil identified in the table as prime farmland, measures that overcome droughtiness are needed. Onsite evaluation is needed to determine whether or not the limitation has been overcome by corrective measures.

In some areas, land that does not meet the criteria for prime is considered to be *farmland of statewide importance* for the production of food, feed, fiber, forage, and oilseed crops. The criteria for defining and delineating farmland of statewide importance are determined by the appropriate State agencies. Generally, this land includes areas of soils that nearly meet the requirements for prime farmland and that economically produce high yields of crops when treated and managed according to acceptable farming methods. Some areas may produce as high a yield as prime farmland if conditions are favorable. Farmland of statewide importance may include tracts of land that have been designated for agriculture by State law.

Hydric Soils

Table 4 lists the map unit components that are rated as hydric soils in the park. This list can help in planning land uses; however, onsite investigation is recommended to

determine the hydric soils on a specific site (National Research Council, 1995; Hurt and Vasilas, 2006).

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology (Cowardin and others, 1979; U.S. Army Corps of Engineers, 1987; National Research Council, 1995; Tiner, 1985). Criteria for all of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. Hydric soils that have been converted to other uses should be capable of being restored to wetlands.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in “Soil Taxonomy” (Soil Survey Staff, 1999) and “Keys to Soil Taxonomy” (Soil Survey Staff, 2010) and in the “Soil Survey Manual” (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in “Field Indicators of Hydric Soils in the United States” (Hurt and Vasilas, 2006).

Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. This depth may be greater if determination of an appropriate indicator so requires. It is always recommended that soils be excavated and described to the depth necessary for an understanding of the redoximorphic processes. Then, using the completed soil descriptions, soil scientists can compare the soil features required by each indicator and specify which indicators have been matched with the conditions observed in the soil. The soil can be identified as a hydric soil if at least one of the approved indicators is present.

Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform.

The criteria for hydric soils are represented by codes in the table (for example, 2B3). Definitions for the codes are as follows:

1. All Histels except for Folistels, and Histosols except for Folists.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
   A. are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
   B. are poorly drained or very poorly drained and have either:
      1) a water table at the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or

2) a water table at a depth of 0.5 foot or less during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches, or

3) a water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 in/hr in any layer within a depth of 20 inches.

3. Soils that are frequently ponded for long or very long duration during the growing season.
4. Soils that are frequently flooded for long or very long duration during the growing season.

Land Management

In tables 5a through 5d, interpretive ratings are given for various aspects of land management. The ratings are both verbal and numerical.

Some rating class terms indicate the degree to which the soils are suited to a specified land management practice. *Well suited* indicates that the soil has features that are favorable for the specified practice and has no limitations. Good performance can be expected, and little or no maintenance is needed. *Moderately suited* indicates that the soil has features that are moderately favorable for the specified practice. One or more soil properties are less than desirable, and fair performance can be expected. Some maintenance is needed. *Poorly suited* indicates that the soil has one or more properties that are unfavorable for the specified practice. Overcoming the unfavorable properties requires special design, extra maintenance, and costly alteration. *Unsuited* indicates that the expected performance of the soil is unacceptable for the specified practice or that extreme measures are needed to overcome the undesirable soil properties.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified land management practice (1.00) and the point at which the soil feature is not a limitation (0.00).

Rating class terms for *fire damage* and *seedling mortality* are expressed as low, moderate, and high. Where these terms are used, the numerical ratings indicate gradations between the point at which the potential for fire damage or seedling mortality is highest (1.00) and the point at which the potential is lowest (0.00).

Rating class terms for *hazard of erosion* are expressed as slight, moderate, severe, and very severe. Where these terms are used, the numerical ratings indicate gradations between the point at which the potential for erosion is highest (1.00) and the point at which the potential is lowest (0.00).

The paragraphs that follow indicate the soil properties considered in rating the soils for land management practices.

Table 5a

Ratings in the columns *suitability for hand planting* and *suitability for mechanical planting* are based on slope, depth to a restrictive layer, content of sand, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, moderately suited, poorly suited, or unsuited to these methods of planting. It is assumed that necessary site preparation is completed before seedlings are planted.

Ratings in the column *soil rutting hazard* are based on depth to a water table, rock fragments on or below the surface, the Unified classification, depth to a restrictive layer, and slope. Ruts form as a result of the operation of planting equipment. The hazard is described as slight, moderate, or severe. A rating of *slight* indicates that the soil is subject to little or no rutting, *moderate* indicates that rutting is likely, and *severe* indicates that ruts form readily.

Table 5b

Ratings in the column *hazard of erosion* are based on slope and on soil erodibility factor K. The soil loss is caused by sheet or rill erosion in areas where 50 to 75 percent of the surface has been exposed by different kinds of disturbance. The hazard is described as slight, moderate, severe, or very severe. A rating of *slight* indicates that erosion is unlikely under ordinary climatic conditions; *moderate* indicates that some erosion is likely and that erosion-control measures may be needed; *severe* indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and *very severe* indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Ratings in the column *hazard of erosion on roads and trails* are based on the soil erodibility factor K, slope, and content of rock fragments. The ratings apply to unsurfaced roads and trails. The hazard is described as slight, moderate, or severe. A rating of *slight* indicates that little or no erosion is likely; *moderate* indicates that some erosion is likely, that the roads or trails may require occasional maintenance, and that simple erosion-control measures are needed; and *severe* indicates that significant erosion is expected, that the roads or trails require frequent maintenance, and that costly erosion-control measures are needed.

Ratings in the column *suitability for roads (natural surface)* are based on slope, rock fragments on the surface, plasticity index, content of sand, the Unified classification, depth to a water table, ponding, flooding, and the hazard of soil slippage. The ratings indicate the suitability for using the natural surface of the soil for roads. The soils are described as well suited, moderately suited, or poorly suited to this use.

Table 5c

Ratings in the column *suitability for mechanical site preparation (deep)* are based on slope, depth to a restrictive layer, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, poorly suited, or unsuited to this management activity. The part of the soil from the surface to a depth of about 3 feet is considered in the ratings.

Ratings in the column *suitability for mechanical site preparation (surface)* are based on slope, depth to a restrictive layer, plasticity index, rock fragments on or below the surface, depth to a water table, and ponding. The soils are described as well suited, poorly suited, or unsuited to this management activity. The part of the soil from the surface to a depth of about 1 foot is considered in the ratings.

Table 5d

Ratings in the column *potential for damage to soil by fire* are based on texture of the surface layer, content of rock fragments and organic matter in the surface layer, thickness of the surface layer, and slope. The soils are described as having a low, moderate, or high potential for this kind of damage. The ratings indicate an evaluation of the potential impact of prescribed fires or wildfires that are intense enough to remove the duff layer and consume organic matter in the surface layer.

Ratings in the column *potential for seedling mortality* are based on flooding, ponding, depth to a water table, content of lime, reaction, salinity, available water capacity, soil moisture regime, soil temperature regime, aspect, and slope. The soils are described as having a low, moderate, or high potential for seedling mortality.

Recreation

The soils of the park are rated in tables 6a and 6b according to limitations that affect their suitability for recreation. The ratings are both verbal and numerical. Rating class

terms indicate the extent to which the soils are limited by all of the soil features that affect the recreational uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The ratings in the tables are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils that are subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

The information in the tables can be supplemented by other information in this survey, for example, interpretations for building site development, construction materials, and water management.

Table 6a

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The ratings are based on the soil properties that affect the ease of developing camp areas and the performance of the areas after development. Slope, stoniness, and depth to bedrock or a cemented pan are the main concerns affecting the development of camp areas. The soil properties that affect the performance of the areas after development are those that influence trafficability and promote the growth of vegetation, especially in heavily used areas. For good trafficability, the surface of camp areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The ratings are based on the soil properties that affect the ease of developing picnic areas and that influence trafficability and the growth of vegetation after development. Slope and stoniness are the main concerns affecting the development of picnic areas. For good trafficability, the surface of picnic areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. The soil properties that influence trafficability are texture of the surface layer, depth to a water table, ponding, flooding, permeability, and large stones. The soil properties that affect the growth of plants are depth to bedrock or a cemented pan, permeability, and toxic substances in the soil.

Table 6b

Foot traffic and equestrian trails for hiking and horseback riding should require little or no slope modification through cutting and filling. The ratings are based on the soil properties that affect trafficability and erodibility. These properties are stoniness, depth to a water table, ponding, flooding, slope, and texture of the surface layer.

Mountain bike and off-road vehicle trails require little or no site preparation. They are not covered with surfacing material or vegetation. Considerable compaction of the soil material is likely. The ratings are based on the soil properties that influence erodibility, trafficability, dustiness, and the ease of revegetation. These properties are stoniness, depth to a water table, ponding, slope, flooding, and texture of the surface layer.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. Ratings are given for building site development, landscaping, sanitary facilities, construction materials, and water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the “Soil Properties” section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about particle-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 7 feet of the surface, soil wetness, depth to a water table, ponding, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kinds of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to evaluate the potential of areas for residential, commercial, and recreational uses; make preliminary estimates of construction conditions; evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; evaluate alternative sites for septic tank absorption fields and sewage lagoons; plan detailed onsite investigations of soils and geology; locate potential sources of gravel, sand, earthfill, and topsoil; plan drainage systems, ponds, and other structures for soil and water conservation; and predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil map, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Dwellings and Small Commercial Buildings

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. Table 7 shows the degree and kind of soil limitations that affect dwellings and small commercial buildings.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Dwellings are single-family houses of three stories or less. For dwellings without basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. For dwellings with basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of about 7 feet. The ratings for dwellings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility. Compressibility is inferred from the Unified classification. The properties that affect the ease and amount of excavation include depth to a water table, ponding, flooding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Small commercial buildings are structures that are less than three stories high and do not have basements. The foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. The ratings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility (which is inferred from the Unified classification). The properties that affect the ease and amount of excavation include flooding, depth to a water table, ponding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Roads and Streets, Shallow Excavations, and Landscaping

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction,

and maintenance. Table 8 shows the degree and kind of soil limitations that affect local roads and streets, shallow excavations, and landscaping.

The ratings in the table are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

Landscaping requires soils on which turf, trees, and shrubs can be established and maintained. Irrigation is not considered in the ratings. The ratings are based on the soil properties that affect plant growth and trafficability after vegetation is established. The properties that affect plant growth are reaction; depth to a water table; ponding; depth to bedrock or a cemented pan; the available water capacity in the upper 40 inches; the content of salts, sodium, or calcium carbonate; and sulfidic materials. The properties that affect trafficability are flooding, depth to a water table, ponding, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer.

Sewage Disposal

Table 9 shows the degree and kind of soil limitations that affect septic tank absorption fields and sewage lagoons. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by

special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches or between a depth of 24 inches and a restrictive layer is evaluated. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. Saturated hydraulic conductivity (K_{sat}), depth to a water table, ponding, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Stones and boulders, ice, and bedrock or a cemented pan interfere with installation. Subsidence interferes with installation and maintenance. Excessive slope may cause lateral seepage and surfacing of the effluent in downslope areas.

Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet below the distribution lines. In these soils the absorption field may not adequately filter the effluent, particularly when the system is new. As a result, the ground water may become contaminated.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Considered in the ratings are slope, saturated hydraulic conductivity (K_{sat}), depth to a water table, ponding, depth to bedrock or a cemented pan, flooding, large stones, and content of organic matter.

Saturated hydraulic conductivity (K_{sat}) is a critical property affecting the suitability for sewage lagoons. Most porous soils eventually become sealed when they are used as sites for sewage lagoons. Until sealing occurs, however, the hazard of pollution is severe. Soils that have a K_{sat} rate of more than 14 micrometers per second are too porous for the proper functioning of sewage lagoons. In these soils, seepage of the effluent can result in contamination of the ground water. Ground-water contamination is also a hazard if fractured bedrock is within a depth of 40 inches, if the water table is high enough to raise the level of sewage in the lagoon, or if floodwater overtops the lagoon.

A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor. If the lagoon is to be uniformly deep throughout, the slope must be gentle enough and the soil material must be thick enough over bedrock or a cemented pan to make land smoothing practical.

Source of Gravel and Sand

Table 10 gives information about the soils as potential sources of gravel and sand. Normal compaction, minor processing, and other standard construction practices are assumed.

Gravel and sand are natural aggregates suitable for commercial use with a minimum of processing. They are used in many kinds of construction. Specifications for each use vary widely. Only the likelihood of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are

factors that affect excavation of the material. The properties used to evaluate the soil as a source of gravel or sand are gradation of grain sizes (as indicated by the Unified classification of the soil), the thickness of suitable material, and the content of rock fragments. If the bottom layer of the soil contains gravel or sand, the soil is considered a likely source regardless of thickness. The assumption is that the gravel or sand layer below the depth of observation exceeds the minimum thickness. The ratings are for the whole soil, from the surface to a depth of about 6 feet.

The soils are rated *good, fair,* or *poor* as potential sources of gravel and sand. A rating of *good* or *fair* means that the source material is likely to be in or below the soil. The bottom layer and the thickest layer of the soils are assigned numerical ratings. These ratings indicate the likelihood that the layer is a source of gravel or sand. The number 0.00 indicates that the layer is a poor source. The number 1.00 indicates that the layer is a good source. A number between 0.00 and 1.00 indicates the degree to which the layer is a likely source.

Source of Reclamation Material, Roadfill, and Topsoil

Table 11 gives information about the soils as potential sources of reclamation material, roadfill, and topsoil. Normal compaction, minor processing, and other standard construction practices are assumed.

The soils are rated *good, fair,* or *poor* as potential sources of reclamation material, roadfill, and topsoil. The features that limit the soils as sources of these materials are specified in the table. Numerical ratings between 0.00 and 0.99 are given after the specified features. These numbers indicate the degree to which the features limit the soils as sources of reclamation material, roadfill, or topsoil. The lower the number, the greater the limitation.

Reclamation material is used in areas that have been drastically disturbed by surface mining or similar activities. When these areas are reclaimed, layers of soil material or unconsolidated geological material, or both, are replaced in a vertical sequence. The reconstructed soil favors plant growth. The ratings in the table do not apply to quarries and other mined areas that require an offsite source of reconstruction material. The ratings are based on the soil properties that affect erosion and stability of the surface and the productive potential of the reconstructed soil. These properties include the content of sodium, salts, and calcium carbonate; reaction; available water capacity; erodibility; texture; content of rock fragments; and content of organic matter and other features that affect fertility.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments. The ratings are for the whole soil, from the surface to a depth of about 5 feet. It is assumed that soil layers will be mixed when the soil material is excavated and spread.

The ratings are based on the amount of suitable material and on soil properties that affect the ease of excavation and the performance of the material after it is in place. The thickness of the suitable material is a major consideration. The ease of excavation is affected by large stones, depth to a water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the AASHTO classification of the soil) and linear extensibility (shrink-swell potential).

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area. The ratings are based on the soil properties that affect plant growth; the ease of excavating, loading, and spreading the material; and reclamation of the borrow area. Toxic substances, soil reaction, and the properties that are inferred from soil texture, such as available water capacity and

fertility, affect plant growth. The ease of excavating, loading, and spreading is affected by rock fragments, slope, depth to a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, depth to a water table, rock fragments, depth to bedrock or a cemented pan, and toxic material.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Ponds and Embankments

Table 12 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed excavated ponds. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the saturated hydraulic conductivity (K_{sat}) of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. Embankments that have zoned construction (core and shell) are not considered. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, K_{sat} of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey.

Soil properties are ascertained by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine particle-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help to characterize key soils.

The estimates of soil properties are shown in tables. They include engineering properties, physical and chemical properties, and pertinent soil and water features.

Engineering Properties

Table 13 gives the engineering classifications and the range of engineering properties for the layers of each soil in the park.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. “Loam,” for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, “gravelly.”

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement,

the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

Physical Soil Properties

Table 14 shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the park. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller. If a range is not present, a singular representative value is shown.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (K_{sat}), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at $^1/_3$- or $^1/_{10}$-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water

storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability (K_{sat}) refers to the ability of a soil to transmit water or air. The estimates in the table indicate the rate of water movement, in micrometers per second, when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Shrink-swell potential is the potential of the soil to expand and contract with a loss or gain in moisture. Linear extensibility is used to determine the shrink-swell potential of soils. Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at $^1/_3$- or $^1/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

The shrink-swell potential is *low* if the soil has a linear extensibility of less than 3 percent; *moderate* if 3 to 6 percent; *high* if 6 to 9 percent; and *very high* if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained by returning crop residue to the soil. Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion Properties

Table 15 shows estimates of some erosion factors that affect a soil's potential for different uses. These estimates are given for each layer of every soil for K factors and are given as one rating for the entire soil for the T factor. Values are reported for each soil in the park. Estimates are based on field observations and on test data for these and similar soils.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and K_{sat}. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

The procedure for determining the Kf factor is outlined in Agriculture Handbook 703, "Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)" (USDA–ARS, 1997).

Depth to the upper and lower boundaries of each layer is indicated.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments. In horizons where total rock fragments are 15 percent or more, by volume, the Kw factor is always less than the Kf factor.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size. Soil horizons that do not have rock fragments are assigned equal Kw and Kf factors.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the “National Soil Survey Handbook” (USDA–NRCS, n.d.)

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Total Soil Carbon

Table 16 gives estimates of total soil carbon. Soil carbon occurs as organic and inorganic carbon.

Soil organic carbon (SOC) is carbon in soil that originated from a biological source, such as plants, animals, or micro-organisms. SOC is found in both organic and mineral soil layers. The term “soil organic carbon” refers only to the carbon occurring in soil organic matter (SOM). Soil organic carbon makes up about one-half the weight of soil organic matter. The rest of SOM is mostly oxygen, nitrogen, and hydrogen.

Soil inorganic carbon (SIC) is carbon found in soil carbonates, typically as calcium carbonate layers in the soil or as clay-sized fractions throughout the soil. Carbonates in soils are most common in areas where evaporation rates exceed precipitation, as is the case in most desert environments. Typically, the carbonates accumulated from carbonatic dust or from solution during periods of wetter climates. Soil inorganic carbon also occurs in soils that formed in marl in all regions of the country.

The SOC and SIC contents are reported in kilograms per square meter to a depth of 2 meters or to a representative depth of either hard bedrock or a cemented horizon. The SOC and SIC values are on a whole soil basis, corrected for rock fragments.

SOC can be an indicator of overall soil fertility and soil quality that affects ecosystem function. SOM is the main reservoir for most plant nutrients, such as phosphorus and nitrogen. Managing for SOC by managing for SOM increases the content of these elements and improves soil resiliency.

Soil organic matter binds soil particles together and thus increases soil porosity and water infiltration and allows better root penetration and waterflow into the soil. Greater inflow of water reduces the hazard of erosion and the rate of surface water runoff.

Greater SOC levels improve not only soil quality but also the quality of air and water. Soil acts as a filter and improves water quality. Fertile soils that support plant life remove CO_2 from the atmosphere and increase oxygen levels through photosynthesis. Maintaining the level of soil organic carbon reduces release of carbon into the atmosphere and thus can lessen the effects of global warming.

SIC influences the types of plants that grow. High SIC levels are commonly associated with a higher soil pH, which limits the types of plants that thrive.

Like SOM, soil carbonates, the source of SIC, also bind soil particles together. They fill voids in the soil and thus can reduce soil porosity. Compacted soil carbonates may restrict root penetration and waterflow into the soil.

Chemical Soil Properties

Table 17 shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Soil reaction is a measure of acidity or alkalinity. The pH of each soil horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced permeability and aeration, and a general degradation of soil structure.

Water Features

Table 18 gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the

surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The table indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Soil Features

Table 19 gives estimates of various soil features. The estimates are used in land use planning that involves engineering considerations.

A *restrictive layer* is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers. The table indicates the hardness and thickness of the restrictive layer, both of

which significantly affect the ease of excavation. *Depth to top* is the vertical distance from the soil surface to the upper boundary of the restrictive layer.

Potential for frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (K_{sat}), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel or concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel or concrete in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low, moderate,* or *high,* is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion also is expressed as *low, moderate,* or *high.* It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

Soils are named and classified on the basis of physical and chemical properties in their horizons (layers). Color, texture, structure, and other properties of the soil to a depth of 2 meters are used to key the soil into a classification system. This system helps people to use soil information and also provides a common language for scientists.

Soils and their horizons differ from one another, depending on how and when they formed. Soil scientists use the five soil-forming factors to help predict where different soils may occur. The degree and expression of the soil horizons reflect the extent of interaction of the soil-forming factors with one or more of the soil-forming processes (Simonson, 1959).

When mapping soils, a soil scientist looks for areas with similar soil-forming factors to find similar soils. The properties of the soils are described. Soils are given taxonomic names based on the properties. Soils are classified, mapped, and interpreted on the basis of various kinds of soil horizons and their arrangement. The distribution of soil orders corresponds with the general patterns of the soil-forming factors within the park.

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1999 and 2010). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. The categories are defined in the following paragraphs.

ORDER. Soil taxonomy identifies 12 soil orders at the highest hierarchical level. The names for the orders and taxonomic soil properties relate to Greek, Latin, or other root words that reveal something about the soil. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol.* An example is Entisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. Sixty-four suborders are recognized at this level of classification. The last syllable in the name of a suborder indicates the order. An example is Orthents (*Orth,* meaning common, plus *ents,* from Entisols).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; type of saturation; and base status. There are about 300 great groups. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Xerorthents (*Xer,* meaning dry, or xeric, moisture regime, plus *orthents,* the suborder of the Entisols that is common).

SUBGROUP. Soil taxonomy identifies more than 2,400 subgroups. Each great group has a typic subgroup. The typic subgroup is the central concept of the great group; it is not necessarily the most extensive. Other subgroups are intergrades or extragrades. Intergrades are transitions to other orders, suborders, or great groups.

Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other taxonomic class. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Lithic* identifies the subgroup that is shallow (less than 20 inches deep) over rock. An example is Lithic Xerorthents.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties for family placement are those of horizons below traditional plow depth. Among the properties and characteristics considered are particle-size class, mineralogy class, cation-exchange activity class, soil temperature regime, soil depth, and reaction class. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is loamy, mixed, nonacid, thermic Lithic Xerorthents.

SERIES. The soil series is the lowest category in the soil classification system. The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. An example is the Gaviota series. Soils in the Gaviota series are loamy, mixed, nonacid, thermic Lithic Xerorthents.

Most parks are mapped to the series level. The names of soil series are selected by the soil scientists during the course of mapping. The series names are commonly geographic place names. Because of access limitations and soil variability, some soils in remote areas are only classified to the great group or subgroup level.

Table 20, “Taxonomic Classification of the Soils,” indicates the order, suborder, great group, subgroup, and family of the soil series in the park. Some of the classifications in the table are considered out-of-date.

Formation of the Soils

By Susan Burlew Southard, Natural Resources Conservation Service.

This section describes the factors of soil formation and relates them to the soils in Cabrillo National Monument, California.

Setting

The setting and geology of the park are related to the parent materials and therefore to the types of soils in the park. Understanding the soils of the park enhances understanding of the unique relationship between soils and the environment. Soil-forming processes are influenced by rock type, topographic expression, surface properties, and hydrologic properties. Because soil formation influences soil properties and behaviors, an understanding of the processes of soil formation may help in the determination of best management practices.

Cabrillo National Monument sits at the end of a naturally beautiful promontory. The monument consists of 160 acres at the tip of the Point Loma peninsula, which reaches an elevation of 422 feet. It is bordered on the west by the Pacific Ocean, on the east and south by San Diego Bay, and on the north by an urban environment (USDI–NPS, 2013).

The average annual temperature is 64 degrees F, and the average annual rainfall is a scant 9.5 inches. Rainfall is concentrated in the winter, from November to April, but the amount can change drastically from year to year. It ranges from 3.4 to 19.4 inches annually (USDI–NPS, 2013). This variability in rainfall causes certain types of plants to thrive one year and barely survive another. The rain is supplemented when cold air from the ocean meets balmy air on the land and dense fogs roll in. The fog provides moisture that allows species requiring more water to coexist with the desert plants and animals. The ocean also keeps air temperatures mild year-round.

The Point Loma peninsula has nearly 80 million years of geologic history. The Point Loma Formation is a prominent geologic feature of the park. It is a large, Cretaceous (about 76 million-year-old) submarine fan and associated debris flows and submarine channels. Other geologic features include Quaternary marine terraces, faults, coastal erosion features (e.g., tide pools), and eolian and colluvial deposits (Abbott and Rockwell, 2004).

Factors of Soil Formation

Soil covers the surface of the earth as a three-dimensional body of varying thickness. It is made up of different proportions of organic and mineral material and pore spaces filled with gases and water. Soils differ in their appearance, productivity, and management requirements due to their chemical and physical properties. The characteristics and properties of soils are determined by physical and chemical processes that result from the interaction of five soil-forming factors. These factors of soil formation are interdependent, and few generalizations can be made regarding any one factor unless the effects of the other factors are known. The term “pedogenesis” is often used to refer to the processes of soil formation.

The interacting soil-forming factors are parent material, climate, organisms, time, and relief and topography (Jenny, 1941). Parent material is the source material in which soils formed. Soils are influenced by the texture and structure of the parent material and its mineralogical and chemical composition. The predominant aspects of climate that affect soil formation are temperature and kind and amount of precipitation. The seasonal distribution of temperature and precipitation also has an influence. Organisms include humans and the plants, animals, and microorganisms living in and on the soil. Time refers to how long the soil-forming factors have been operating on a particular landscape. Relief and topography refer to the shape and elevation of the landscape. They affect internal and external soil properties, such as soil drainage, aeration, susceptibility to erosion, and exposure to the sun and wind.

The processes of soil formation are sequences of events, involving biogeochemical reactions that are energized by climate and spatially related to relief and topography (Buol and others, 2011). The physical and chemical properties of a soil are altered by these reactions over time.

The influence of each factor varies. Soils may differ significantly from place to place in a park and within very short distances as a result of complex interaction among the five factors. In some instances, however, parks may have vast stretches of the same type of soil because of uniform soil-forming factors.

Parent Material

The unconsolidated mass in which soils form is called “parent material.” Mineral soils are a product of the weathering of underlying bedrock in place or the weathering of mineral material that has been transported. Organic soils form in place from the accumulation and decomposition of plant material, such as wood, leaves, and aquatic plants. Weathering refers to the chemical and physical disintegration and decomposition of parent material. Few soils weather directly from the underlying rocks. More commonly, soils form in materials that been transported from elsewhere. Soils generally have one dominant kind of parent material but are influenced by other types of parent material. Material may have been moved only a few feet by gravity (colluvial parent material) or transported long distances by wind (eolian parent material) or water (alluvial parent material). Soils are said to have residual parent material if they formed directly from underlying rocks or from an in situ plant source.

Soils that formed in residuum may have the same general chemistry as the original rocks, depending on the degree of weathering that has occurred. The soils of Cabrillo National Monument formed in part from a combination of residuum from sandstone and colluvium derived from the eroding cliffs of the Cabrillo Formation (fig. 3). For example, the Gaviota soils formed from residuum and colluvium. They are shallow soils that have contact with hard bedrock within a depth of 20 inches (table 19). At Point Loma, colluvium accumulates at the base of road cuts and near the scarps of old landslides. Some of the landslide deposits in the park are fairly large and include a mix of both bedrock and soil material. Figure 4 shows the results of a landslide above the tide pool area. The colluvial material becomes parent material for new soils. Colluvium mantles most of the lower marine terraces in the park. All the soils that formed in colluvium in the park are weakly developed. They show little evidence of weathering.

Most of the soils in the park also have some influence from windblown sands (eolian parent material). The sand sources include sand dunes and beach ridges of the geologic past and recent sand deposits. Eolian processes played a role in the landscape of the Point Loma peninsula in the geologic past. The peninsula is composed of sandstone which is, in part, lithified dunes covered by unconsolidated, windblown sand.

Figure 5 shows a high beach ridge on the highest terrace in the park. The beach ridge is parallel to the coastline and is superimposed on uplifted wave-cut marine terraces at variable elevations above sea level. Carlsbad soils are on the uplifted

Figure 3.—An area of Gaviota soil in a road cut along the Bayside Trail. This soil is shallow and formed in a combination of colluvium and residuum derived from sandstone. The brush that does not have any leaves and appears to be dead is *California encelia,* which drops its leaves during dry seasons and goes dormant.

Figure 4.—An area where a landslide has resulted in a mix of colors. Landslide material becomes colluvial parent material for new soils on the hillslope.

Figure 5.—A view looking west from the parking lot of the Visitor Center at Cabrillo National Monument. The light-colored beach ridge on the horizon is mapped as Carlsbad soil.

beach ridges in the park, including areas around the Point Loma historic lighthouse. Marine terraces are uplifted strips of coastline that were originally formed at and just below the surf line. They were mantled by marine sediments and then overlain by materials eroded from the coast (KellerLynn, 2008). The present-day wave-cut platforms exposed at the edge of the ocean and along the tide-pool area are derived from marine sandstone of the Point Loma Formation (fig. 6). Wave-cut platforms are the narrow flat areas at the base of the cliffs. The platforms were created by the action of waves. Wave-cut platforms form the tide pools in the park. The variable elevations of the ridges, terraces, and platforms are due to faulting, uplift, and erosion. The erosion processes in the park have included stream entrenchment, deflation, surface water erosion, and wave-cut encroachment of the sea cliffs (Southard and Flach, 1995).

Figure 6.—Wave-cut platforms along the western edge of the park. At the left side of the photo are red, eroding paleosols that are buried by lighter colored eolian sands.

The Carlsbad soil probably formed, in part, from material that is referred to as a “paleosol.” Paleosols are soils that formed when the soil-forming environment (e.g. climate and landscape position) was different than it is now. A paleosol can be a buried soil or an exhumed, previously buried soil. The chemical composition and morphology of a paleosol reflect different conditions than those that exist today. The paleosols in the park have become lithified and are geologic members of the Cabrillo and Point Loma Formations (Abbott, 1981). The paleosols in the park have preserved evidence of dramatic climate shifts over time. As shown in the pictures figures 7 and 8, paleosols in the park look very much like current soils in the southeastern coastal plain of North Carolina. This suggests that the climate in Southern California, which is now hot and dry, was much wetter when these soils were formed. At depth, Carlsbad soils have

Figure 7.—Redoximorphic features along a root channel in a wet soil of the coastal plain in the southeastern United States (Kelley, 2007a). Some redoximorphic features become plinthite when dried.

Figure 8.—Redoximorphic features that have dried to plinthite and then cemented in paleosols at Cabrillo National Monument. The image on the left shows a closeup area about 2 feet by 3 feet taken at the cliffs in the center-left of the image on the right.

a horizon of slight clay accumulation and then, at variable depth, a silica-cemented horizon. The cemented zone, or silica-cemented hardpan, is a duripan. The lithified paleosol is below the duripan. Paleosols are important because they provide clues about past climates.

Reticulate mottling is a feature of paleosols at Cabrillo National Monument. Reticulate mottling consists of a network of mottles or redoximorphic features. These features are commonly associated with plinthite. Plinthite is a redoximorphic feature in mineral soils. It forms from the segregation of iron and aluminum in a mixture of clay and quartz. If plinthite is repeatedly subject to wetting and drying, it hardens irreversibly to form ironstone (Soil Survey Staff, 1999).

Figure 7 shows plinthite in a present-day soil of the southeastern coastal plain of the United States. Figure 8 shows plinthite in the paleosols of the park. In the park, reticulate mottling has hardened into ironstone (i.e. plinthite) of the Cabrillo Formation. Figures 9 and 10 compare horizontal views of plinthite in the paleosols of Cabrillo National Monument, California, with a present-day soil of the southeastern United States.

Figure 9.—Horizontal view of reticulate mottling in a paleosol at Cabrillo National Monument. The term “reticulate” defines the well-defined pattern or network of soil colors. The view shown is about 1 foot by 1 foot. This exposure is located north of the Whale Overlook (see fig. 2).

Figure 10.—Horizontal view of present-day reticulate mottling in a soil of the coastal plain in the southeastern United States (Kelley, 2007b). This area receives 5 times more precipitation than the present-day Cabrillo area.

Carlsbad soils frequently have small pebbles, which are either iron-manganese or iron-titanium (ilmenite) concretions (White, 1979). Soil scientists refer to these concretions as a redoximorphic feature called "concentrations." Concentrations form as a result of oxidation-reduction reactions. The number of concretions in the Carlsbad soils seems to vary with the location on the relict beach ridge. Excavations were not made to confirm the existence of such concretions within the park. However, the concretions are known to exist north of the park in other locations where Carlsbad soils are mapped in San Diego County.

Concretions are commonly round, cemented minerals embedded in host rock or in soils that have different composition and morphology than the concretions. The cementing agents are carried by water. The concretionary cement commonly makes the concretions harder and more resistant to weathering than the soil or host rock. The word "concretion" is derived from the Latin "con," meaning "together," and "cresco," meaning "to grow" (Katz, 1999).

If the concretions are broken apart, they display concentric rings illustrating different growth events, much like tree rings. The rings are caused by concentric precipitation around the center of an initiating object. A small fossil, pebble, or piece of plant or shell associated with the depositional environment acted as a nucleus to start the precipitation of minerals around it. Wet environments provided the source of the nucleus objects. The environment in which the concretions "grew" determined their size, composition, and distribution.

Concretions are commonly associated with shale, siltstone, and sandstone because the original sources of these sedimentary rocks were wet depositional environments subject to oxidation and reduction by iron-rich groundwater. The groundwater associated with the landscape of Cabrillo National Monument would have been iron-rich due to the granitic pluton that underlies the San Diego area. The concretions formed in a much wetter climate than exists today.

Concretions also formed in paleoclimates in other properties of the National Park Service. Red concretions in Theodore Roosevelt National Park in North Dakota can be up to 10 feet in diameter. These concretions are red because iron minerals (hematite and goethite) were in the carbonate-rich environment where they formed. Concretions called “Moqui marbles” are found at national parks in Utah, including Zion, Arches, Capitol Reef, and Canyonlands, where there are significant amounts of Navajo sandstone (Chan and Parry, 2002). Navajo sandstone, in a past environment, was conducive to formation of concretions. The concretions subsequently became incorporated in some of the desert soils as the Navajo sandstone weathered. Figure 11 displays concretions from Carlsbad soil mapped in the vicinity of Point Loma and from soil associated with Navajo sandstone in Utah.

Figure 11.—Six red concretions from the Carlsbad soil of San Diego County in the upper part of the image and a Moqui marble associated with Navajo sandstone of Utah in the lower part. Small concretions also occur in Cabrillo National Monument.

Carlsbad soils have been affected by present and past climatic conditions. The paleosols below the Carlsbad soils formed on a different landscape than exists today and in a wetter climate. The paleosols have distinct morphological features, such as the numerous concretions, resulting from a soil-forming environment that no longer exists on the site.

Iron concretions and reticulate mottling are currently forming in soils that have wet conditions in which iron-rich sediments become oxidized and reduced. Concretions (concentrations) form in soils when reduced iron in solution becomes oxidized and then is precipitated as hematite or goethite. In coastal tidal marshes in England, concretions have been found in which the center was forming around fragments of bombs and other military shrapnel from World War II (Al-Agha and others, 1995).

Alluvium is parent material deposited by running water. Alluvium can have different textures, depending on the speed of the water. The type of rocks in the source region of the streams and rivers also determines the characteristics of the alluvium. Fast-moving water deposits gravel, rocks, and sand. Slow-moving water deposits fine textured material (clay and silt) when sediments in the water settle out. Exposures of the Cabrillo Formation along Cabrillo Road and Sylvester Road (the bayside trail) show the variable composition of the original alluvial material that was deposited in the geologic past and subsequently lithified and uplifted. Some strata have large pebbles, and some are pure lithified sand (fig. 12). When these formations weather, they create colluvial materials that influence the characteristics of the soils forming on the slopes. Most of the colluvial soils forming on the marine terrace contain variable amounts of rounded rocks because the source of the colluvium was originally alluvial material having water-worked fragments of variable sizes and composition.

Figure 12.—Close-up view of variable shapes and sizes of materials comprising a lithified beach ridge. This ridge is also shown in the distance in figure 5.

Climate

Differences in climate can result in differences in soils. Temperature and moisture influence soil formation and are the two most commonly measured features of climate. Weathering is most active when soils are moist and warm because these conditions are conducive to rapid chemical reactions and increased biological activity in the soil. Cooler temperatures result in slower chemical reactions. Although average temperatures and precipitation are important in determining soil properties, the extremes of climate also have a major role in soil formation at any specific locale.

During periods of rainfall, water carries dissolved or suspended solids through the soil in a process called "leaching." The leaching process becomes active with the onset of rainfall. Variations in temperature and moisture cause variations in weathering and leaching in the soil. Seasonal and daily changes in temperature affect moisture effectiveness, biological activity, rates of chemical reactions, and kinds of vegetation.

Present-day climate variations are the result of topography and relief. Fluctuations in temperature and moisture affect the rates of production, decomposition, and accumulation of organic matter and of weathering of minerals. In the park, mean annual precipitation is 10 to 16 inches and mean annual temperature is about 62 degrees F. The average temperature is 55 degrees F in January and 69 degrees F in July. The average frost-free season is 330 to 350 days.

In most areas of the United States, temperature generally decreases with elevation and precipitation generally increases with elevation. The soils on summits and the soils on western exposures in the park, however, are drier than the other soils in the park. The soils are drier because the summits and western exposures are exposed to high winds. Also, the summits are above the low-lying marine fog and are warmer than low-lying areas (fig. 13). This reversal is due to the low-lying marine fog and local

Figure 13.—Seasonal, morning coastal fog along the southern California coastal plain. Such fog is common.

temperature inversions. Some tree species, such as Monterey cypress *(Cupressus macrocarpa),* are effective at capturing moisture from fog as it condenses on needles. The moisture then drops to the ground and infiltrates the soil, becoming readily available to tree, grass, and shrub roots.

Wind redistributes sand, salts, and other particles in arid and semiarid regions. The soils of Cabrillo National Monument have been affected by windblown sands and salt spray from the ocean. Some plants, such as Coast saltbush *(Atriplex lentiformis),* are effective at removing salts from soil water. Bladders in the leaves act as salt sinks, removing the salt from the plant cells (USDI–NPS, July 2012). When the leaves die, the salt is returned to the soil.

The climate makes the park susceptible to wildfires. Wildfires can influence soil-forming processes. After a fire, erosion may be accelerated by the loss of vegetation and surface ground cover. Heavy precipitation loosens rock and soil on slopes that lack the stabilizing effect of plant roots. Unconsolidated rock and soils that are suddenly saturated with water can detach and slide downslope, causing a slump or flow.

Organisms

Plants, animals, microorganisms, and humans affect the formation and shape of soils. Plants capture solar energy via photosynthesis and transfer that energy to the soil, energy that is a fundamental driver of many soil processes. Fungi and bacteria are the primary organisms that decompose organic matter and add nutrients to the soil. Microorganisms affect chemical exchanges between roots and soil. Animals and microorganisms mix soils and form burrows and pores. Humans also can mix soils extensively by various activities.

Plant roots open channels in the soils. Different types of roots have different effects on soils. Grass roots are fibrous and decompose easily, adding organic matter to the soil. Fine grass roots can extend below the surface for many feet. Large tree roots can fracture rocks and create paths of water flow. Taproots open pathways through dense layers. Abandoned tunnels commonly are filled with loose material from the overlying horizons and transmit water more readily than the surrounding undisturbed soil material.

Plant roots also help to develop soil structure and aggregate stability. Vegetation increases soil stability by protecting the surface against wind and water erosion. Leaves from plants fall to the surface and decompose on the soil. Organisms decompose these leaves and mix them with the upper part of the soil, resulting in cycling of nutrients and energy back to vegetation. The leaf litter, both leaves and needles, helps prevent nutrient loss, conserves soil moisture, reduces raindrop impact, and limits frost penetration.

The influence of parent material and other soil-forming factors on soil determines the development of ecological niches in a park. The influence of parent material on soil depth and soil chemistry dictates the types of vegetation in specific areas. The coastal sage scrub community of the park survives in an ecosystem that rarely freezes in the winter and only occasionally experiences temperatures over 90 degrees F during the summer, which is dry.

The coastal sage scrub and chaparral ecological communities evolved in response to climatic changes that began about 14 million years ago. Mediterranean climate belts developed in both the northern and southern hemispheres on the western coastline of the continents. These climate belts are approximately between 30 and 40 degrees latitude. Mediterranean climate belts receive an average of 10 to 20 inches of rainfall a year and only occasionally experience frost. These areas typically have winter rains and dry, warm summers with fairly constant temperatures. At these latitudes, average rainfall decreased from 80 inches or more per year in the Eocene Epoch (34 to 56

million years ago) to only about 12 inches per year by the middle of the Miocene Epoch (5 to 23 million years ago) (USDI–NPS, July 2012).

Habitats evolved along with the landscape, which continues to influence soil formation and plant species. San Diego spineflower *(Chorizanthe orcuttiana),* which is an endangered annual flowering plant, grows on sandy, neutral or slightly acidic soils that have a low content of organic matter. Examples of eolian-influenced habitats are dunes and sand deposition in the intertidal zone and draping marine terraces. Specific locations of eolian features include dunes on the bayside and coastal dune habitat on Navy land (USDI–NPS, July 2012). Table 17 shows some of the ranges of pH, salinity, and sodium content of the soils. Salinity levels are higher in Huerhuero and Reiff soils, which are along the ocean, than in the other soils.

Coastal sage scrub plants have adapted to store moisture and reduce moisture loss when the soils are dry because of the prolonged hot, dry weather between April and October. The plants conserve water either by specialized leaf structures or through dormancy. Tough, leathery, wax-covered leaves, such as those of the lemonadeberry shrub *(Rhus integrifolia),* prevent water from escaping through leaf pores. Minute white hairs reduce fruit temperatures of the plant by reflecting sunlight. The hairs also reduce moisture loss by reducing wind speed. Other plants drop their leaves during summer months, thereby recycling their nutrients in the soil. California encelia *(Encelia californica)* is a plant that drops its leaves during the dry seasons. The leaves return nutrients to the soil when they decompose.

Other species, especially flowering ones, dry up and are dormant by middle summer. Although they appear to be dead, they are just dormant and growth is still occurring in the roots. Root systems can be extensive, sometimes reaching more than 30 feet into the soil and fractured rock. The roots anchor the plants and hold soil in place, reducing runoff during winter and spring rains.

The coastline of southern California was once covered by coastal sage scrub but is now largely urban land. Only scattered pockets remain of this endangered habitat. Cabrillo National Monument is an example. Native plants found in the park today are part of the coastal sage scrub community that the explorer Juan Rodriguez Cabrillo encountered when he landed in the area in 1542. Then, as now, the community was composed of an association of woody shrubs ranging in height from 1 to 10 feet and including white sage *(Salvia apiana),* black sage *(Salvia mellifera),* California buckwheat *(Eriogonum fasciculatum),* toyon *(Heteromeles arbutifolia),* and lemonadeberry (USDI–NPS, July 2012). The native vegetation depends on climate, topography, biological factors, and many soil factors, including soil density, depth, chemistry, temperature, and moisture. The plants and animals in this habitat have adapted to arid coastal climates and to soils that are shallow, rocky, and sandy.

The plant and soil communities in the park are adapted to both drought and fire. Fire is a healthy and necessary component of their life cycle. Shrubs respond to recurrent fires in several ways. They re-sprout from both crown and roots, and they produce seeds, commonly at an early age. The seeds are both fire resistant and dependent on fire for germination. Fire creates a healthy plant mosaic of different ages and species. As a result, fire increases the diversity of habitats.

When burned, chaparral vegetation may result in areas of fire-induced soil hydrophobicity. Hydrophobic soils repel water. A thin layer of soil at or below the mineral soil surface can become hydrophobic after intense heating. The hydrophobic layer is the result of a waxy substance that is derived when volatile oils and other organic compounds from plants are vaporized during a hot fire and then recondense in the cooler soil just beneath the surface. Water absorption is prevented by the waxy layer of hydrophobic soil that forms. Because the ground cover is often destroyed by the fire, hydrophobic soils have increased runoff and erosion. Clayey soils are the most resistant to developing hydrophobicity. The predominantly sandy or loamy soils of Point Loma in the park are much more susceptible if they have chaparral vegetation.

Time

Time is an important factor affecting soil formation. Over time, soils exhibit features that reflect the interaction of other soil-forming factors. Recently deposited material, such as material deposited by a flood, does not exhibit features from soil development activities and has properties that are unchanged by soil formation. If the previous soil surface and underlying horizons become buried, the clock resets for formation of the soil. The different horizons in a soil profile and the degree of development can be directly related to time. Terraces high above the ocean are older than terraces adjacent to the ocean, and thus the soils on the higher terraces exhibit more horizon development than the soils on the terraces adjacent to the ocean.

Gaviota soils, which are on hillslopes, have few distinctive profile characteristics (fig. 14). The pale brown Carlsbad loamy sand soils, which have concretions and duripan horizons, are on stable, uplifted marine terraces that have had time to develop weak profile characteristics. The hardness of the weakly cemented layer varies with seasonal water content.

Figure 14.—View of a hillslope mapped as Gaviota fine sandy loam, 30 to 50 percent slopes. On top of the hill is the northern most parking lot in the park and an area of upper beach ridge (upper right corner of the image). A marine terrace covered by colluvial material is in the foreground.

Topography and Relief

Topography refers to the shape of the landscape, and relief refers to differences in elevation. The overall landscape in an area, including terraces, hillslopes, and escarpments, is the result of erosion and depositional processes. These processes may have occurred in response to changes in climate, fluctuating sea levels, and/or tectonic activities. Episodes of landscape stability and instability influence the types of soils that form.

Slope and aspect of the overall landscape can affect the moisture and temperature of the soil. Steep slopes facing the sun are warmest. Steep soils can erode and lose their surface horizons as they form. Thus, steeper soils may be thinner than more nearly level soils that receive deposits from areas upslope. Deeper, darker soils may be expected on the lower lying, level landscapes. Soil-forming factors continue to affect soils even on “stable” landscapes. Materials are deposited on their surface, and materials are blown or washed away from their surface. Additions, removals, and alterations can be slow or rapid, depending on climate, landscape position, and biological activity. Figure 15 shows exposures of eroded, marine-terrace paleosols above tide pools. These terrace soils do not have plinthite and reticulate mottling, suggesting they formed in a different climate than the upper level paleosols.

Marine terraces of the park are uplifted, abandoned strips of coastline. They formed in the surf zone, are mantled by marine sediments and fossils, and are overlain by “terrestrial sediments.” The terrestrial sediments are deposited either by eolian, alluvial, or colluvial processes that originated on land. The terrestrial sediments become soils as they are transformed by soil-forming factors. The soils can have different degrees of formation depending on the age and stability of the terrace. The 900,000-year-old Linda Vista upper terrace is the oldest terrace in Cabrillo (Abbott, 1981). It has plinthic paleosols underlying the Carlsbad soils. The youngest marine

Figure 15.—Eroding, marine terrace soils above the tide pools. A thin mantle of eolian sands covers the present-day soil. Redder, buried paleosols are visible at lower depths.

platforms are the substrate for tidal pools, kelp forests, and reefs at the monument. Figures 16 and 17 capture typical landscapes of Cabrillo National Monument.

Figure 16.—View north from the Kelp Forest and Whale Overlook (see fig. 2). Plinthite paleosols are on the exposed ledge on the right. The area above the ledge is Carlsbad gravelly loamy sand, 9 to 15 percent slopes. The foreground and area along Cabrillo Road are Gaviota fine sandy loam, 30 to 50 percent slopes.

Figure 17.—The horizontally stratified rocks starting at the water are wave-cut platforms. The cliffs above the platforms are eroded marine terraces. The sloping soils in the center of the image are marine terrace soils that have been undercut by coastal erosion.

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the “National Soil Survey Handbook” (available in local offices of the Natural Resources Conservation Service or on the Internet).

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Aquic conditions. Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Aspect. The direction toward which a slope faces. Also called slope aspect.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Backslope. The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology). A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bench terrace. A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks. A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Brush management. Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Chemical treatment. Control of unwanted vegetation through the use of chemicals.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions. See Redoximorphic features.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Claypan. A dense, compact, slowly permeable subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. A claypan is commonly hard when dry and plastic and sticky when wet.

Coarse textured soil. Sand or loamy sand.

Cobble (or cobblestone). A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

COLE (coefficient of linear extensibility). See Linear extensibility.

Colluvium. Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope. Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions. See Redoximorphic features.

Conglomerate. A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Consistence, soil. Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the "Soil Survey Manual."

Coprogenous earth (sedimentary peat). A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology). A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations). Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Crown. The upper part of a tree or shrub, including the living branches and their foliage.

Dense layer (in tables). A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depth, soil. Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement. A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth. A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Drainage class (natural). Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface. Runoff, or surface flow of water, from an area.

Drainageway. A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Duff. A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune. A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Ecological site. An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eolian deposit. Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the

building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion pavement. A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface. A land surface shaped by the action of erosion, especially by running water.

Escarpment. A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope. A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil. Sandy clay, silty clay, or clay.

Flood plain. The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain step. An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial. Of or pertaining to rivers or streams; produced by stream or river action.

Footslope. The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb. Any herbaceous plant not a grass or a sedge.

Forest cover. All trees and other woody plants (underbrush) covering the ground in a forest.

Fragipan. A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gravel. Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Ground water. Water filling all the unblocked pores of the material below the water table.

Hard bedrock. Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology). A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

Hill. A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope. A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

L horizon.—A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties are depth to a seasonal high water table, the infiltration rate and permeability after prolonged wetting, and depth to a very

slowly permeable layer. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Intermittent stream. A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Iron depletions. See Redoximorphic features.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

K_{sat}. Saturated hydraulic conductivity. (See Permeability.)

Lacustrine deposit. Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Landslide. A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward

deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones (in tables). Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

Linear extensibility. Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^{1}/_{3}$- or $^{1}/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength. The soil is not strong enough to support loads.

Map unit. A map unit is a collection of areas defined and named the same in terms of their soil components or miscellaneous (nonsoil) areas or both. Each map unit differs in some respect from all others in a survey area, and each has a symbol that uniquely identifies the map unit on a soil map. Each individual polygon, point, or line so identified on the map is referred to as a delineation.

Map unit component. A distinct kind of soil, generally a phase of a taxonomic unit, or miscellaneous (nonsoil) area within a soil map unit. Components can be categorized as either major or minor. The names of major components are used to name the map unit. Each component of a map unit has a unique set of soil properties that differentiates it from other components within the same map unit. Each is assigned a designated range in proportionate extent (percent) within the map unit.

Marl. An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Mass movement. A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses. See Redoximorphic features.

Mechanical treatment. Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Miscellaneous area. A kind of map unit that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon. A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties

of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain. A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck. Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mudstone. A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation. A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules. See Redoximorphic features.

Nose slope (geomorphology). A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low	less than 0.5 percent
Low	0.5 to 1.0 percent
Moderately low	1.0 to 2.0 percent
Moderate	2.0 to 4.0 percent
High	4.0 to 8.0 percent
Very high	more than 8.0 percent

Paleoterrace. An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Paleosol. A soil that formed in a particular area with distinctive features resulting from a soil-forming environment that no longer exists in the area.

Pan. A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The movement of water through the soil.

Permeability. The quality of the soil that enables water or air to move downward through the profile. The rate at which a saturated soil transmits water is accepted as a measure of this quality. In soil physics, the rate is referred to as “saturated hydraulic conductivity,” which is defined in the “Soil Survey Manual.” In line with conventional usage in the engineering profession and with traditional usage in published soil surveys, this rate of flow continues to be expressed as “permeability.” Terms describing permeability, measured in inches per hour, are as follows:

Impermeable	less than 0.0015 inch
Very slow	0.0015 to 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil. A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology). A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Plinthite. The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings. See Redoximorphic features.

Potential native plant community. See Climax plant community.

Prescribed burning. Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Rangeland. Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid	less than 3.5
Extremely acid	3.5 to 4.4
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Moderately acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Slightly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Redoximorphic concentrations. See Redoximorphic features.

Redoximorphic depletions. See Redoximorphic features.

Redoximorphic features. Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix. See Redoximorphic features.

Relief. The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material). Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill. A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser. The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut. A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil. A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone. Sedimentary rock containing dominantly sand-sized particles.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (K_{sat}). See Permeability.

Saturation. Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Sedimentary rock. A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Series, soil. A group of soils that have profiles that are almost alike. All the soils of a given series have horizons that are similar in composition, thickness, and arrangement.

Shale. Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shoulder. The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell (in tables). The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Side slope (geomorphology). A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone. An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium. Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

Sodicity. The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^+ to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight	less than 13:1
Moderate	13-30:1
Strong	more than 30:1

Sodium adsorption ratio (SAR). A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock. Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Stone line. In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stream terrace. One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summit. The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil. The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terrace (conservation). An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology). A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer (in tables). Otherwise suitable soil material that is too thin for the specified use.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope. The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread. The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Upland. An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Weathering. All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth’s surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Tables

Table 1.--Soil Legend

Map unit symbol and map unit name	Components in map unit	Percent of map unit
456763:		
Carlsbad gravelly loamy sand, 5 to 9 percent slopes	Carlsbad	85
	Chesterton	5
	Marina	5
	Redding	2
	Unnamed, ponded	2
	Unnamed	1
456764:		
Carlsbad gravelly loamy sand, 9 to 15 percent slopes	Carlsbad	85
	Chesterton	5
	Unnamed	5
	Marina	2
	Redding	2
	Unnamed	1
456822:		
Gaviota fine sandy loam, 9 to 30 percent slopes	Gaviota	85
	Linne	10
	Diablo	3
	Huerhuero	2
456823:		
Gaviota fine sandy loam, 30 to 50 percent slopes	Gaviota	85
	Linne	10
	Diablo	3
	Huerhuero	2
456875:		
Loamy alluvial land-Huerhuero complex, 9 to 50 percent slopes, severely eroded	Huerhuero	30
	Loamy alluvial land	30
	Carlsbad	2
	Chesterton	2
	Huerhuero	2
	Unnamed	1
456912:		
Reiff fine sandy loam, 0 to 2 percent slopes	Reiff	85
	Plecentia	5
	Ramona	5
	Visalia	5
456914:		
Reiff fine sandy loam, 5 to 9 percent slopes	Reiff	85
	Placentia	5
	Ramona	5
	Visalia	5
456932:		
Steep gullied land	Steep gullied land	85
	Unnamed	1

Table 2.--Land Capability Classification

[Land capability classification is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. Only the soils suitable for cultivation are listed. "N" stands for nonirrigated; "I" stands for irrigated]

Map unit symbol and component name	Land capability	
	N	I
456763:		
Carlsbad	3e	3e
456764:		
Carlsbad	4e	4e
456822:		
Gaviota	4e	---
456823:		
Gaviota	6e	---
456875:		
Huerhuero	7e	6e
456912:		
Reiff	3c	1
456914:		
Reiff	3e	3e

Table 3.--Prime Farmland and Other Important Farmland

[Only the soils considered prime or important farmland are listed. Urban or built-up areas of the soils listed are not considered prime or important farmland. If a soil is prime or important farmland only under certain conditions, the conditions are indicated in the column "Farmland classification"]

Map unit symbol	Map unit name	Farmland classification
456763	Carlsbad gravelly loamy sand, 5 to 9 percent slopes	Farmland of statewide importance
456764	Carlsbad gravelly loamy sand, 9 to 15 percent slopes	Farmland of statewide importance
456912	Reiff fine sandy loam, 0 to 2 percent slopes	Prime farmland where irrigated
456914	Reiff fine sandy loam, 5 to 9 percent slopes	Farmland of statewide importance

Table 4.--Hydric Soils

[This report lists only those map unit components that are rated as hydric. Definitions of hydric criteria codes are included at the end of the report]

Map unit symbol and map unit name	Component	Percent of map unit	Landform	Hydric soils criteria: Hydric criteria code	Meets saturation criteria	Meets flooding criteria	Meets ponding criteria
456763: Carlsbad gravelly loamy sand, 5 to 9 percent slopes	Unnamed, ponded	2	Depressions	3	No	No	Yes
	Unnamed	1	Sloughs	3	No	No	Yes
456764: Carlsbad gravelly loamy sand, 9 to 15 percent slopes	Unnamed	1	Sloughs	3	No	No	Yes
456875: Loamy alluvial land-Huerhuero complex, 9 to 50 percent slopes, severely eroded	Unnamed	1	Drainageways	2B3	Yes	No	No
456932: Steep gullied land	Unnamed	1	Depressions	2B3	Yes	No	No

Explanation of hydric criteria codes

1. All Histels (except for Folistels), and Histosols (except for Folists), which are, by definition, saturated.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
   - A. are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
   - B. are poorly drained or very poorly drained and have either:
     - 1.) a water table at the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or
     - 2.) a water table at a depth of 0.5 foot or less during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches, or
     - 3.) a water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 in/hr in any layer within a depth of 20 inches.
3. Soils that are frequently ponded for periods of long or very long duration during the growing season.
4. Soils that are frequently flooded for periods of long or very long duration during the growing season.

Table 5a.--Land Management, Part I (Planting)

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Suitability for hand planting		Suitability for mechanical planting		Soil rutting hazard	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
456763:							
Carlsbad------------	85	Moderately suited		Moderately suited		Moderate	
		Sandiness	0.50	Slope	0.50	Low strength	0.50
				Sandiness	0.50		
456764:							
Carlsbad------------	85	Moderately suited		Moderately suited		Moderate	
		Sandiness	0.50	Slope	0.50	Low strength	0.50
				Sandiness	0.50		
456822:							
Gaviota-------------	85	Well suited		Poorly suited		Moderate	
				Slope	0.75	Low strength	0.50
456823:							
Gaviota-------------	85	Moderately suited		Unsuited		Moderate	
		Slope	0.50	Slope	1.00	Low strength	0.50
456875:							
Huerhuero-----------	30	Moderately suited		Poorly suited		Severe	
		Stickiness; high plasticity index	0.50	Slope	0.75	Low strength	1.00
				Stickiness; high plasticity index	0.50		
Loamy alluvial land-	30	Not rated		Not rated		Not rated	
456912:							
Reiff---------------	85	Well suited		Well suited		Moderate	
						Low strength	0.50
456914:							
Reiff---------------	85	Well suited		Moderately suited		Moderate	
				Slope	0.50	Low strength	0.50
456932:							
Steep gullied land--	85	Not rated		Not rated		Not rated	

Table 5b.--Land Management, Part II (Hazard of Erosion and Suitability for Roads)

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Hazard of erosion: Rating class and limiting features	Value	Hazard of erosion on roads and trails: Rating class and limiting features	Value	Suitability for roads (natural surface): Rating class and limiting features	Value
456763:							
Carlsbad	85	Slight		Moderate		Moderately suited	
				Slope/erodibility	0.50	Sandiness	0.50
						Slope	0.50
456764:							
Carlsbad	85	Slight		Moderate		Moderately suited	
				Slope/erodibility	0.50	Slope	0.50
						Sandiness	0.50
456822:							
Gaviota	85	Moderate		Severe		Poorly suited	
		Slope/erodibility	0.50	Slope/erodibility	0.95	Slope	1.00
456823:							
Gaviota	85	Severe		Severe		Poorly suited	
		Slope/erodibility	0.75	Slope/erodibility	0.95	Slope	1.00
456875:							
Huerhuero	30	Moderate		Severe		Poorly suited	
		Slope/erodibility	0.50	Slope/erodibility	0.95	Slope	1.00
						Low strength	0.50
Loamy alluvial land	30	Not rated		Not rated		Not rated	
456912:							
Reiff	85	Slight		Slight		Well suited	
456914:							
Reiff	85	Slight		Moderate		Moderately suited	
				Slope/erodibility	0.50	Slope	0.50
456932:							
Steep gullied land	85	Not rated		Not rated		Not rated	

Table 5c.--Land Management, Part III (Site Preparation)

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Suitability for mechanical site preparation (deep)		Suitability for mechanical site preparation (surface)	
		Rating class and limiting features	Value	Rating class and limiting features	Value
456763:					
Carlsbad	85	Well suited		Well suited	
456764:					
Carlsbad	85	Well suited		Well suited	
456822:					
Gaviota	85	Poorly suited		Poorly suited	
		Slope	0.50	Slope	0.50
456823:					
Gaviota	85	Unsuited		Unsuited	
		Slope	1.00	Slope	1.00
456875:					
Huerhuero	30	Poorly suited		Poorly suited	
		Slope	0.50	Slope	0.50
Loamy alluvial land	30	Not rated		Not rated	
456912:					
Reiff	85	Well suited		Well suited	
456914:					
Reiff	85	Well suited		Well suited	
456932:					
Steep gullied land	85	Not rated		Not rated	

Table 5d.--Land Management, Part IV (Site Restoration)

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Potential for damage to soil by fire		Potential for seedling mortality	
		Rating class and limiting features	Value	Rating class and limiting features	Value
456763:					
Carlsbad	85	High		Low	
		Texture/rock fragments	1.00		
456764:					
Carlsbad	85	High		Low	
		Texture/rock fragments	1.00		
456822:					
Gaviota	85	Moderate		Low	
		Texture/rock fragments	0.50		
456823:					
Gaviota	85	Moderate		Low	
		Texture/rock fragments	0.50		
456875:					
Huerhuero	30	High		Low	
		Texture/surface depth/rock fragments	1.00		
Loamy alluvial land	30	Not rated		Not rated	
456912:					
Reiff	85	Moderate		Low	
		Texture/rock fragments	0.50		
456914:					
Reiff	85	Moderate		Low	
		Texture/rock fragments	0.50		
456932:					
Steep gullied land	85	Not rated		Not rated	

Table 6a.--Recreation, Part I (Camp and Picnic Areas)

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Camp areas: Rating class and limiting features	Camp areas: Value	Picnic areas: Rating class and limiting features	Picnic areas: Value
456763:					
Carlsbad	85	Somewhat limited		Somewhat limited	
		Too sandy	0.79	Too sandy	0.79
		Gravel	0.18	Gravel	0.18
456764:					
Carlsbad	85	Somewhat limited		Somewhat limited	
		Slope	0.63	Slope	0.63
		Too sandy	0.79	Too sandy	0.79
		Gravel	0.18	Gravel	0.18
		Depth to cemented pan	0.20	Depth to cemented pan	0.20
456822:					
Gaviota	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00
456823:					
Gaviota	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Depth to bedrock	1.00
456875:					
Huerhuero	30	Very limited		Very limited	
		Slope	1.00	Slope	1.00
		Sodium content	1.00	Sodium content	1.00
		Slow water movement	0.45	Slow water movement	0.45
Loamy alluvial land	30	Not rated		Not rated	
456912:					
Reiff	85	Not limited		Not limited	
456914:					
Reiff	85	Not limited		Not limited	
456932:					
Steep gullied land	85	Not rated		Not rated	

Table 6b.--Recreation, Part II (Trail Management)

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Foot traffic and equestrian trails: Rating class and limiting features	Foot traffic and equestrian trails: Value	Mountain bike and off-road vehicle trails: Rating class and limiting features	Mountain bike and off-road vehicle trails: Value
456763:					
Carlsbad	85	Somewhat limited		Somewhat limited	
		Too sandy	0.79	Too sandy	0.79
456764:					
Carlsbad	85	Somewhat limited		Somewhat limited	
		Too sandy	0.79	Too sandy	0.79
456822:					
Gaviota	85	Somewhat limited		Not limited	
		Slope	0.50		
456823:					
Gaviota	85	Very limited		Very limited	
		Slope	1.00	Slope	1.00
456875:					
Huerhuero	30	Very limited		Very limited	
		Water erosion	1.00	Water erosion	1.00
		Slope	0.92		
Loamy alluvial land	30	Not rated		Not rated	
456912:					
Reiff	85	Not limited		Not limited	
456914:					
Reiff	85	Not limited		Not limited	
456932:					
Steep gullied land	85	Not rated		Not rated	

Table 7.--Dwellings and Small Commercial Buildings

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Dwellings without basements		Dwellings with basements		Small commercial buildings	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
456763:							
Carlsbad	85	Not limited		Not limited		Somewhat limited	
						Slope	0.88
456764:							
Carlsbad	85	Somewhat limited		Somewhat limited		Very limited	
		Slope	0.63	Slope	0.63	Slope	1.00
				Depth to thin cemented pan	0.20		
456822:							
Gaviota	85	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Slope	1.00
		Slope	1.00	Slope	1.00	Depth to hard bedrock	1.00
456823:							
Gaviota	85	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
456875:							
Huerhuero	30	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell potential	1.00	Shrink-swell potential	1.00	Shrink-swell potential	1.00
Loamy alluvial land	30	Not rated		Not rated		Not rated	
456912:							
Reiff	85	Not limited		Not limited		Not limited	
456914:							
Reiff	85	Not limited		Not limited		Somewhat limited	
						Slope	0.88
456932:							
Steep gullied land	85	Not rated		Not rated		Not rated	

Table 8.--Roads and Streets, Shallow Excavations, and Landscaping

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Local roads and streets: Rating class and limiting features	Value	Shallow excavations: Rating class and limiting features	Value	Landscaping: Rating class and limiting features	Value
456763:							
Carlsbad	85	Not limited		Very limited		Somewhat limited	
				Unstable excavation walls	1.00	Droughty	0.73
						Gravel	0.18
456764:							
Carlsbad	85	Somewhat limited		Very limited		Somewhat limited	
		Slope	0.63	Unstable excavation walls	1.00	Droughty	0.97
						Slope	0.63
				Slope	0.63	Depth to cemented pan	0.20
				Depth to thin cemented pan	0.20		
						Gravel	0.18
456822:							
Gaviota	85	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to bedrock	1.00
						Droughty	1.00
		Slope	1.00	Slope	1.00	Slope	1.00
				Unstable excavation walls	0.10		
456823:							
Gaviota	85	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to bedrock	1.00
						Slope	1.00
		Slope	1.00	Slope	1.00	Droughty	1.00
				Unstable excavation walls	0.10		
456875:							
Huerhuero	30	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Shrink-swell potential	1.00	Unstable excavation walls	1.00	Sodium content	1.00
						Droughty	0.99
		Low strength	1.00				
Loamy alluvial land	30	Not rated		Not rated		Not rated	
456912:							
Reiff	85	Not limited		Somewhat limited		Not limited	
				Unstable excavation walls	0.10		
456914:							
Reiff	85	Not limited		Somewhat limited		Not limited	
				Unstable excavation walls	0.10		
456932:							
Steep gullied land	85	Not rated		Not rated		Not rated	

Table 9.--Sewage Disposal

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Septic tank absorption fields		Sewage lagoons	
		Rating class and limiting features	Value	Rating class and limiting features	Value
456763:					
Carlsbad	85	Very limited		Very limited	
		Depth to cemented pan	1.00	Depth to cemented pan	1.00
				Seepage	1.00
				Slope	1.00
456764:					
Carlsbad	85	Very limited		Very limited	
		Depth to cemented pan	1.00	Depth to cemented pan	1.00
		Slope	0.63	Slope	1.00
				Seepage	1.00
456822:					
Gaviota	85	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00
		Seepage, bottom layer	1.00	Seepage	1.00
456823:					
Gaviota	85	Very limited		Very limited	
		Depth to bedrock	1.00	Depth to hard bedrock	1.00
		Slope	1.00	Slope	1.00
		Seepage, bottom layer	1.00	Seepage	1.00
456875:					
Huerhuero	30	Very limited		Very limited	
		Slow water movement	1.00	Slope	1.00
		Slope	1.00		
Loamy alluvial land	30	Not rated		Not rated	
456912:					
Reiff	85	Very limited		Very limited	
		Seepage, bottom layer	1.00	Seepage	1.00
456914:					
Reiff	85	Very limited		Very limited	
		Seepage, bottom layer	1.00	Seepage	1.00
				Slope	1.00
456932:					
Steep gullied land	85	Not rated		Not rated	

Table 10.--Source of Gravel and Sand

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The ratings given for the thickest layer are for the thickest layer above and excluding the bottom layer. The numbers in the value columns range from 0.00 to 0.99. The greater the value, the greater the likelihood that the bottom layer or thickest layer of the soil is a source of sand or gravel. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Gravel source		Sand source	
		Rating class	Value	Rating class	Value
456763:					
Carlsbad	85	Poor		Fair	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.10
456764:					
Carlsbad	85	Poor		Fair	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.10
456822:					
Gaviota	85	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
456823:					
Gaviota	85	Poor		Poor	
		Bottom layer	0.00	Bottom layer	0.00
		Thickest layer	0.00	Thickest layer	0.00
456875:					
Huerhuero	30	Poor		Fair	
		Bottom layer	0.00	Thickest layer	0.00
		Thickest layer	0.00	Bottom layer	0.08
Loamy alluvial land	30	Not rated		Not rated	
456912:					
Reiff	85	Poor		Fair	
		Bottom layer	0.00	Bottom layer	0.03
		Thickest layer	0.00	Thickest layer	0.03
456914:					
Reiff	85	Poor		Fair	
		Bottom layer	0.00	Bottom layer	0.03
		Thickest layer	0.00	Thickest layer	0.03
456932:					
Steep gullied land	85	Not rated		Not rated	

Table 11.--Source of Reclamation Material, Roadfill, and Topsoil

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.00 to 0.99. The smaller the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Source of reclamation material: Rating class and limiting features	Value	Roadfill source: Rating class and limiting features	Value	Topsoil source: Rating class and limiting features	Value
456763:							
Carlsbad	85	Poor		Poor		Poor	
		Droughty	0.00	Depth to cemented pan	0.00	Too sandy	0.02
		Too sandy	0.02			Rock fragments	0.00
		Too acid	0.84				
456764:							
Carlsbad	85	Poor		Poor		Poor	
		Droughty	0.00	Depth to cemented pan	0.00	Too sandy	0.02
		Too sandy	0.02			Rock fragments	0.00
		Depth to cemented pan	0.80			Depth to cemented pan	0.80
456822:							
Gaviota	85	Poor		Poor		Poor	
		Droughty	0.00	Depth to bedrock	0.00	Depth to bedrock	0.00
		Depth to bedrock	0.00	Slope	0.50	Slope	0.00
		Low content of organic matter	0.88			Rock fragments	0.88
456823:							
Gaviota	85	Poor		Poor		Poor	
		Droughty	0.00	Depth to bedrock	0.00	Depth to bedrock	0.00
		Depth to bedrock	0.00	Slope	0.00	Slope	0.00
		Low content of organic matter	0.88			Rock fragments	0.88
456875:							
Huerhuero	30	Poor		Poor		Poor	
		Sodium content	0.00	Low strength	0.00	Sodium content	0.00
		Too clayey	0.00	Shrink-swell potential	0.73	Slope	0.00
		Droughty	0.21			Too clayey	0.00
				Slope	0.08		
Loamy alluvial land	30	Not rated		Not rated		Not rated	
456912:							
Reiff	85	Fair		Good		Good	
		Low content of organic matter	0.12				
456914:							
Reiff	85	Fair		Good		Good	
		Low content of organic matter	0.12				
456932:							
Steep gullied land	85	Not rated		Not rated		Not rated	

Table 12.--Ponds and Embankments

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the limitation. See text for further explanation of ratings in this table]

Map unit symbol and soil name	Pct. of map unit	Pond reservoir areas		Embankments, dikes, and levees		Aquifer-fed excavated ponds	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
456763:							
Carlsbad	85	Very limited		Very limited		Very limited	
		Seepage	1.00	Seepage	1.00	Depth to water	1.00
		Slope	0.92	Thin layer	0.52		
		Depth to cemented pan	0.52				
456764:							
Carlsbad	85	Very limited		Very limited		Very limited	
		Seepage	1.00	Seepage	1.00	Depth to water	1.00
		Slope	1.00	Thin layer	0.77		
		Depth to cemented pan	0.77				
456822:							
Gaviota	85	Very limited		Very limited		Very limited	
		Slope	1.00	Thin layer	1.00	Depth to water	1.00
		Depth to bedrock	1.00				
456823:							
Gaviota	85	Very limited		Very limited		Very limited	
		Slope	1.00	Thin layer	1.00	Depth to water	1.00
		Depth to bedrock	1.00				
456875:							
Huerhuero	30	Very limited		Very limited		Very limited	
		Slope	1.00	Piping	1.00	Depth to water	1.00
		Seepage	0.03				
Loamy alluvial land	30	Very limited		Not rated		Not rated	
		Slope	1.00				
456912:							
Reiff	85	Very limited		Not limited		Very limited	
		Seepage	1.00			Depth to water	1.00
456914:							
Reiff	85	Very limited		Not limited		Very limited	
		Seepage	1.00			Depth to water	1.00
		Slope	0.92				
456932:							
Steep gullied land	85	Not rated		Not rated		Not rated	

Table 13.--Engineering Properties

[Absence of an entry indicates that data were not estimated]

Map unit symbol and soil name	Depth	USDA texture	Classification		Fragments		Percentage pas sieve number		
			Unified	AASHTO	>10 in	3-10 in	4	10	40
	In				*Pct*	*Pct*			
456763:									
Carlsbad--------	0-21	Gravelly loamy sand	SM	A-1	0	0	80-90	60-75	30-50
	21-39	Loamy sand	SM	A-2, A-1	0	0	95-100	90-100	45-65
	39-50	Indurated	---	---	---	---	---	---	---
456764:									
Carlsbad--------	0-21	Gravelly loamy sand	SM	A-1	0	0	80-90	60-75	30-50
	21-33	Loamy sand	SM	A-2, A-1	0	0	95-100	90-100	45-65
	33-50	Indurated	---	---	---	---	---	---	---
456822:									
Gaviota---------	0-16	Fine sandy loam	SM	A-4	0	0	80-100	75-95	55-70
	16-20	Unweathered bedrock	---	---	---	---	---	---	---
456823:									
Gaviota---------	0-16	Fine sandy loam	SM	A-4	0	0	80-100	75-95	55-70
	16-20	Unweathered bedrock	---	---	---	---	---	---	---
456875:									
Huerhuero-------	0-1	Loam	ML, CL-ML	A-4	0	0	95-100	90-100	80-95
	1-40	Clay loam, clay	CL, CH	A-7	0	0	95-100	90-100	90-10
	40-60	Stratified sand to sandy loam	SC-SM	A-2	0	0	90-100	90-100	50-75
456912:									
Reiff-----------	0-14	Fine sandy loam	SM	A-4	0	0	95-100	85-100	55-85
	14-43	Stratified sandy loam to loam	SM	A-4	0	0	95-100	85-100	55-80
	43-60	Stratified sandy loam to loam	SM	A-4	0	0	95-100	85-100	55-80
456914:									
Reiff-----------	0-14	Fine sandy loam	SM	A-4	0	0	95-100	85-100	55-85
	14-43	Stratified sandy loam to loam	SM	A-4	0	0	95-100	85-100	55-80
	43-60	Stratified sandy loam to loam	SM	A-4	0	0	95-100	85-100	55-80

Table 14.--Physical Soil Properties

[Sand, silt, and clay values are shown either as a range or as a representative value.
indicates that data were not estimated]

Map unit symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Permeability (Ksat)	Available water capacity
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*In/hr*	*In/in*
456763:							
Carlsbad--------	0-21	84	9	5-10	1.60-1.70	2.0-5.9	0.05-0.07
	21-39	84	9	5-10	1.60-1.70	2.0-5.9	0.07-0.09
	39-50	---	---	---	---	---	---
456764:							
Carlsbad--------	0-21	84	9	5-10	1.60-1.70	2.0-5.9	0.05-0.07
	21-33	84	9	5-10	1.60-1.70	2.0-5.9	0.07-0.09
	33-50	---	---	---	---	---	---
456822:							
Gaviota---------	0-16	66	20	10-18	1.50-1.60	2.0-5.9	0.11-0.13
	16-20	---	---	---	---	---	---
456823:							
Gaviota---------	0-16	66	20	10-18	1.50-1.60	2.0-5.9	0.11-0.13
	16-20	---	---	---	---	---	---
456875:							
Huerhuero-------	0-1	42	38	15-25	1.45-1.55	0.6-2.0	0.14-0.18
	1-40	29	31	35-45	1.35-1.45	0.0-0.1	0.03-0.06
	40-60	---	---	5-15	1.50-1.60	0.2-0.6	0.06-0.12
456912:							
Reiff-----------	0-14	67	20	8-18	1.50-1.60	2.0-5.9	0.10-0.13
	14-43	---	---	8-18	1.50-1.60	2.0-5.9	0.14-0.16
	43-60	---	---	8-18	1.50-1.60	2.0-5.9	0.14-0.16
456914:							
Reiff-----------	0-14	67	20	8-18	1.50-1.60	2.0-5.9	0.10-0.13
	14-43	---	---	8-18	1.50-1.60	2.0-5.9	0.14-0.16
	43-60	---	---	8-18	1.50-1.60	2.0-5.9	0.14-0.16

Table 15.--Erosion Properties

[Entries under "Erosion factors" apply to the entire profile. Entries under "Wind erodibility group" and "Wind erodibility index" apply only to the surface layer]

Map unit symbol and soil name	Depth	Erosion factors Kw	Kf	T	Wind erodi- bility group	Wind erodi- bility index
	In					
456763:						
Carlsbad	0-21	.15	.24	2	3	86
	21-39	.32	.32			
	39-50	---	---			
456764:						
Carlsbad	0-21	.15	.24	2	3	86
	21-33	.32	.32			
	33-50	---	---			
456822:						
Gaviota	0-16	.28	.32	1	3	86
	16-20	---	---			
456823:						
Gaviota	0-16	.28	.32	1	3	86
	16-20	---	---			
456875:						
Huerhuero	0-1	.37	.37	2	5	56
	1-40	.32	.32			
	40-60	.32	.32			
Loamy alluvial land.						
456912:						
Reiff	0-14	.28	.32	5	3	86
	14-43	.28	.32			
	43-60	.28	.32			
456914:						
Reiff	0-14	.28	.32	5	3	86
	14-43	.28	.32			
	43-60	.28	.32			
456932:						
Steep gullied land.						

Table 16.--Total Soil Carbon

[This table displays soil organic carbon (SOC) and soil inorganic carbon (SIC) in kilograms per square meter to a depth of 2 meters or to the representative top depth of any kind of bedrock or any cemented soil horizon. SOC and SIC are reported on a volumetric whole-soil basis, corrected for representative rock fragments indicated in the database. SOC is converted from soil organic matter by horizon for the fraction of the soil less than 2 millimeters in diameter. If soil organic matter is indicated in the database as null, SOC is assumed to be zero. SIC is converted from the content of calcium carbonate by horizon in the fraction of the soil less than 2 millimeters in diameter. If the content of calcium carbonate is indicated in the database as null, SIC is assumed to be zero. A weighted average of all horizons is used in the calculations. Only major components of a map unit are displayed]

Map unit symbol, component name, and component percent	SOC	SIC
	kg/m²	*kg/m²*
456763:		
Carlsbad (85 percent)	6	0
456764:		
Carlsbad (85 percent)	6	0
456822:		
Gaviota (85 percent)	3	0
456823:		
Gaviota (85 percent)	3	0
456875:		
Huerhuero (30 percent)	7	0
Loamy alluvial land (30 percent)	0	0
456912:		
Reiff (85 percent)	5	0
456914:		
Reiff (85 percent)	5	0
456932:		
Steep gullied land (85 percent)	0	0

Table 17.--Chemical Soil Properties

[Absence of an entry indicates that data were not estimated]

Map unit symbol and soil name	Depth	Cation-exchange capacity	Soil reaction	Salinity	Sodium adsorption ratio
	In	*meq/100 g*	*pH*	*mmhos/cm*	
456763:					
Carlsbad-------------	0-21	1.0-5.0	5.6-6.5	0	0
	21-39	1.0-5.0	5.1-6.5	0	0
	39-50	---	---	0	0
456764:					
Carlsbad-------------	0-21	1.0-5.0	5.6-6.5	0	0
	21-33	1.0-5.0	5.1-6.5	0	0
	33-50	---	---	0	0
456822:					
Gaviota--------------	0-16	10.0-15.0	7.4-7.8	0	0
	16-20	---	---	0	0
456823:					
Gaviota--------------	0-16	10.0-15.0	7.4-7.8	0	0
	16-20	---	---	0	0
456875:					
Huerhuero------------	0-1	15.0-20.0	5.1-6.0	0	0
	1-40	25.0-35.0	7.4-8.4	0.0-2.0	15-20
	40-60	15.0-20.0	7.4-8.4	0.0-2.0	5-15
456912:					
Reiff----------------	0-14	8.0-14.0	6.1-8.4	0	0
	14-43	8.0-14.0	6.6-8.4	0.0-2.0	0
	43-60	8.0-14.0	6.6-8.4	0.0-2.0	0
456914:					
Reiff----------------	0-14	8.0-14.0	6.1-8.4	0	0
	14-43	8.0-14.0	6.6-8.4	0.0-2.0	0
	43-60	8.0-14.0	6.6-8.4	0.0-2.0	0

Table 18.--Water Features

[See text for definitions of terms used in this table. Estimates of the frequency of ponding and flooding apply to the whole year rather than to individual months. Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Map unit symbol and soil name	Hydro-logic group	Months	Water table: Upper limit	Water table: Lower limit	Ponding: Surface water depth	Ponding: Duration	Ponding: Frequency	Flooding: Duration	Flooding: Frequency
			Ft	*Ft*	*Ft*				
456763:									
Carlsbad	C								
		Jan-Dec	---	---	---	---	None	---	None
456764:									
Carlsbad	C								
		Jan-Dec	---	---	---	---	None	---	None
456822:									
Gaviota	D								
		Jan-Dec	---	---	---	---	None	---	None
456823:									
Gaviota	D								
		Jan-Dec	---	---	---	---	None	---	None
456875:									
Huerhuero	D								
		Jan-Dec	---	---	---	---	None	---	None
Loamy alluvial land	B								
		Jan-Dec	---	---	---	---	None	---	None
456912:									
Reiff	B								
		Jan-Dec	---	---	---	---	None	---	None
456914:									
Reiff	B								
		Jan-Dec	---	---	---	---	None	---	None
456932:									
Steep gullied land	---								
		Jan-Dec	---	---	---	---	None	---	None

Table 19.--Soil Features

[See text for definitions of terms used in this table. Absence of an entry indicates that data were not estimated]

Map unit symbol and soil name	Restrictive layer: Kind	Restrictive layer: Depth to top	Restrictive layer: Thickness	Restrictive layer: Hardness	Potential for frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
		In	*In*				
456763:							
Carlsbad	Duripan	24-40	4-17	Weakly cemented	Low	Moderate	Moderate
456764:							
Carlsbad	Duripan	24-40	4-17	Weakly cemented	Low	Moderate	Moderate
456822:							
Gaviota	Lithic bedrock	10-20	---	Strongly cemented	Low	Moderate	Moderate
456823:							
Gaviota	Lithic bedrock	10-20	---	Strongly cemented	Low	Moderate	Moderate
456875:							
Huerhuero	---	---	---	---	Low	High	Low
Loamy alluvial land	---	---	---	---	Low	---	---
456912:							
Reiff	---	---	---	---	Low	High	Low
456914:							
Reiff	---	---	---	---	Low	High	Low
456932							
Steep gullied land	---	---	---	---	Low	---	---

Table 20.--Taxonomic Classification of the Soils

Soil name	Family or higher taxonomic class
Carlsbad	Sandy, mixed, thermic Entic Durixerepts
Gaviota	Loamy, mixed, superactive, nonacid, thermic Lithic Xerorthents
Huerhuero	Fine, smectitic, thermic Typic Natrixeralfs
Reiff	Coarse-loamy, superactive, mixed, nonacid, thermic Mollic Xerofluvents

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UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

SOIL SURVEY OF CABRILLO NATIONAL MONUMENT, CALIFORNIA
POINT LOMA QUADRANGLE
SHEET NUMBER 1 OF 1

This soil survey was compiled by the U.S. Department of Agriculture, Natural Resources Conservation Service, at the request of the Department of the Interior, National Park Service. Base maps are orthophotographs prepared by the U.S. Department of Agriculture, Farm Service Agency from 2006 - 2011 aerial photographs. A 2012 National Park Service boundary was used. Soil information was derived from USDA/NRCS Soil Survey Geographic (SSURGO) database for Cabrillo National Monument. Universal Transverse Mercator Zone 11 North, North American Datum of 1983 (NAD83).

SCALE 1:24,000

North

Cabrillo National Monument, California

Sheet 1 of 1

Soil Legend

Cabrillo National Monument, California
Soil Survey Area CA638

Soil Map Unit Key	Soil Map Unit Name
456763	Carlsbad gravelly loamy sand, 5 to 9 percent slopes
456764	Carlsbad gravelly loamy sand, 9 to 15 percent slopes
456822	Gaviota fine sandy loam, 9 to 30 percent slopes
456823	Gaviota fine sandy loam, 30 to 50 percent slopes
456875	Loamy alluvial land-Huerhuero complex, 9 to 50 percent slopes, severely eroded
456912	Reiff fine sandy loam, 0 to 2 percent slopes
456914	Reiff fine sandy loam, 5 to 9 percent slopes
456932	Steep gullied land